This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Digitized by Google

NEW
5300
.a

Bound 1941

HARVARD UNIVERSITY

LIBRARY

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

Exchange
11983

Digitized by Google

Digitized by Google

Digitized by Google

11,983

University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the act of August 24, 1912.

Published fortnightly

No. 560 ALBANY, N. Y. FEBRUARY 1, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 169

GEOLOGY OF SARATOGA SPRINGS AND VICINITY

BY

H. P. CUSHING AND R. RUEDEMANN

	PAGE
Introduction	5
Location and character	6
General topography	8
General geology	15
Descriptive geology	16
Historical geology	135
Economic geology	148
Control of development and history of Saratoga region by the geology	168
Index	171

ALBANY.

THE UNIVERSITY OF THE STATE OF NEW YORK

1914

M371-Ap13-2500

Digitized by Google

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of the University
With years when terms expire

1917 St Clair McKelway M.A. LL.D. D.C.L. L.H.D.
Chancellor Brooklyn
1914 Pliny T. Sexton LL.B. LL.D. *Vice Chancellor* Palmyra
1915 Albert Vander Veer M.D. M.A. Ph.D. LL.D. Albany
1922 Chester S. Lord M.A. LL.D. - - - - - New York
1918 William Nottingham M.A. Ph.D. LL.D. - - Syracuse
1921 Francis M. Carpenter - - - - - - - Mount Kisco
1923 Abram I. Elkus LL.B. D.C.L. - - - - - New York
1924 Adelbert Moot - - - - - - - - - - Buffalo
1925 Charles B. Alexander M.A. LL.B. LL.D. Lit.D. Tuxedo
1919 John Moore - - - - - - - - - - - Elmira
1920 Andrew J. Shipman M.A. LL.B. LL.D. - - New York
1916 Walter G. Kellogg - - - - - - - - - Ogdensburg

President of the University
and Commissioner of Education

John H. Finley M.A. LL.D.

Assistant Commissioners

Augustus S. Downing M.A. L.H.D. LL.D. *For Higher Education*
Charles F. Wheelock B.S. LL.D. *For Secondary Education*
Thomas E. Finegan M.A. Pd.D. LL.D. *For Elementary Education*

Director of State Library

James I. Wyer, Jr, M.L.S.

Director of Science and State Museum

John M. Clarke Ph.D. D.Sc. LL.D.

Chiefs of Divisions

Administration, George M. Wiley M.A.
Attendance, James D. Sullivan
Educational Extension, William R. Watson B.S.
Examinations, Harlan H. Horner B.A.
History, James A. Holden B.A.
Inspections, Frank H. Wood M.A.
Law, Frank B. Gilbert B.A.
Library School, Frank K. Walter M.A. M.L.S.
Public Records, Thomas C. Quinn
School Libraries, Sherman Williams Pd.D.
Statistics, Hiram C. Case
Visual Instruction, Alfred W. Abrams Ph.B.
Vocational Schools, Arthur D. Dean D.Sc.

Digitized by Google

New York State Education Department
Science Division, March 28, 1913

Hon. Andrew S. Draper LL.D.
Commissioner of Education

SIR: I have the honor to communicate herewith, and to recommend for publication as a bulletin of the State Museum, a manuscript entitled the *Geology of Saratoga Springs and Vicinity*, with the necessary illustrative matter accompanying.

This report has been prepared at my request by Doctors Cushing and Ruedemann, in response to a public demand for information in regard to the geological conditions existing about and causing the Saratoga mineral springs.

Very respectfully
JOHN M. CLARKE
Director

STATE OF NEW YORK
EDUCATION DEPARTMENT
COMMISSIONER'S ROOM

Approved for publication this 3d day of April 1913

Commissioner of Education

Digitized by Google

Digitized by Google

University of the State of New York Bulletin

Application for entry as second-class matter at the Post Office at Albany, N. Y., pending

Published fortnightly

No. 560 ALBANY, N. Y. FEBRUARY 1, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 169

GEOLOGY OF SARATOGA SPRINGS AND VICINITY

BY

H. P. CUSHING AND R. RUEDEMANN

INTRODUCTION

BY H. P. CUSHING

The presence of a group of well-known springs whose waters are of a somewhat unusual type, has long given prominence to the region about Saratoga. A variety of causes has recently increased this prominence and rendered it desirable that the geology of the region should undergo more thorough investigation than it had ever received, in the hope that light might be shed upon the question of the origin of the waters and the duration of the supply.

It was the original plan to include in this report the geology of the Broadalbin quadrangle, next west of Saratoga, which was assigned to Dr W. J. Miller, but later developments led to the abandonment of this plan and Doctor Miller's report has been published separately.[1] That work was done in close association with our own, and in addition Doctor Miller also mapped some 30 square miles in the extreme northwest corner of the Saratoga quadrangle. This service is emphatically acknowledged since the country concerned is unsettled and difficult of access, and the aid was rendered at a time when the writer was unable to engage in field work as laborious as that which this district entailed. With this exception, Doctor Ruedemann and myself are responsible for the mapping. Much of the territory we have seen together.

[1] N. Y. State Mus. Bul. 153.

Digitized by Google

The classifying and mapping of the shales is wholly Doctor Ruedemann's; and the whole Schuylerville quadrangle also with the trifling exception of the extreme northwest corner.

During the progress of the work an invitation was extended to Prof. J. F. Kemp to collaborate in the study of the spring waters. Circumstances later developed which rendered it advisable to publish the report which he drew up as a separate paper and in advance of the main report.[1] The aid rendered is gratefully acknowledged.

During the progress of the field work several geologists have spent some time with us on the ground, and given most helpful suggestion and counsel. Days spent with Messrs Ulrich, Kemp, Smyth, Van Ingen and Miller are in no slight degree responsible for whatever of merit may lie in this report.

Over much of the Saratoga sheet glacial drift is so widespread and thick as to render hopeless the attempt to accurately map the geology beneath, which is peculiarly unfortunate because the geology is complicated and difficult. This has been the chief, and a very great, drawback to the successful prosecution of the work.

LOCATION AND CHARACTER

BY H. P. CUSHING

These two quadrangles, the Saratoga and Schuylerville, lie in extreme eastern New York, about midway of the State from north to south. The territory included lies between latitude 43° and 43° 15′ N, and longitude 73° 30′ and 74° W, hence extending over ¼° of latitude and ½° of longitude. It falls just short of containing 450 square miles.

The district includes parts of several topographic and geologic provinces. Bits of the southeast margin of the Adirondack highland, included by Powell in the province he called the New England plateaus, are seen. This highland is separated from the high Appalachian plateau of southern New York by the Mohawk valley lowland, a valley eaten out by stream erosion along the belt of weak shales which are the surface rocks through most of it. To this lowland belong the shales of the southern part of the Saratoga quadrangle.

The Adirondack highland is separated from the main mass of the New England plateaus by the low grounds of the Champlain-

[1] N. Y. State Mus. Bul. 159.

Digitized by Google

Hudson trough. This is not a mere valley of erosion but a true trough, having been repeatedly depressed as compared with the districts east and west of it. Erosion has had its part in the development of the valley, but as a secondary instead of a primary factor. In the mapped district this lowland is seen merging into the Mohawk lowland. Across the Hudson, along the east margin of the Schuylerville sheet, rises a range of hills, the outlying western rampart of the New England plateaus.

Turning from topography to geology we find the old crystalline rocks of the Adirondacks coming into the district from the north. These are margined by the flat-lying sandstones, limestones and shales of early Paleozoic age which were deposited in the Champlain basin, even in that early time a sinking trough. These in turn are adjoined on the east by the series of much disturbed shales of the Hudson valley, a quite different series of rocks from those of the Champlain basin. They were deposited, also in early Paleozoic times, in a wholly separate and more easterly trough than the Champlain basin, and have been brought to their present location by being thrust over to the west by the action of great compressive forces. As rocks they are not indigenous to the region, but exotic. Still farther east come the limestones and impure shaly rocks of the Bald Mountain ridge, also overthrust into the district from the east. These rocks are so different from those of the Champlain basin that we are of necessity constrained to describe and discuss them in separate chapters.

In two minor features the geology of the region is unique. One of the Paleozoic formations of the Champlain basin, the fossiliferous, Upper Cambric limestone which was first described by Walcott, occurs as a surface formation in New York only in the immediate vicinity of Saratoga.[1] Just north of Schuylerville there outcrops a knob of extrusive igneous rock, first recognized and described by Woodworth, which is unlike any other known igneous rock of the State, and which has been made to play a part in one theory of the origin of the spring waters.[2]

[1] U. S. Geol. Surv., Bul. 30, p. 21–22.

[2] N. Y. State Geol. 21st Ann. Rep't, p. 117–129, 1901.

Digitized by Google

GENERAL TOPOGRAPHY

BY H. P. CUSHING

ADIRONDACK HIGHLAND

The surface rocks of the Adirondack highland are ancient crystalline rocks of Precambric age. The district is one with an inherent tendency to be elevated and to move upward rather than downward, or at least not to participate in the sagging tendency of adjacent territory during times of oscillations in the crust of the earth. Such a region is spoken of as a positive one, to distinguish it from districts of the negative type, whose tendency is to depress. At certain times in the past the margins of the highland have been sufficiently depressed to pass beneath sea level and become covered by marine deposits. But the central area of the plateau seems never to have been depressed in this manner, or at least not since very early in Precambric time; since then it has had a continuous existence as a land area. From time to time it has been uplifted and its surface has experienced much erosion. Between the periodic uplifts long ages of stability have intervened. During these stable intervals the surface has been the scene of incessant erosion, chiefly by stream and rain action. The ultimate effect of such prolonged erosion on a stable land area is to wear it down to a comparatively even surface with low altitude. Such an erosion plain is called a peneplain. If a peneplained district be again uplifted, stream activity is renewed and the whole erosion process again set in motion.

The Adirondack highland has certainly been peneplained twice during its history, and quite likely more than twice. The earlier of the two peneplains was completed in Precambric time, and it was upon this peneplained surface that the early Paleozoic deposits of northern New York were laid down, about the margins of the Adirondacks. These covered and preserved this old erosion surface and portions of it are reappearing at the present-day surface, as the Paleozoic cover is stripped away from it by modern erosion.[1] Its comparative evenness is surprising, when the great variation of the rocks composing it in resistance to erosion is considered.

In considerable part the present Precambric surfaces of the Saratoga quadrangle represent fragments of this old peneplain, though somewhat modified by comparatively modern erosion. This Precambric peneplain was developed over a wide area and is

[1] N. Y. State Mus. Bul. 145, p. 54-60.

Digitized by Google

recognizable over a large part of Canada and in the Upper Lake region as well as in the Adirondacks.

A much later peneplain, of probable late Mesozoic date, was also developed in the region, and again it was merely the local development of a peneplain of wide extent in eastern North America. Prior to its development, deformation of the region had upwarped the older peneplain into the form of a gentle dome, and at the same time downwarped the margins into shallow troughs in which early Paleozoic sandstones, limestones and shales had been deposited. The Mesozoic peneplain truncated the domed summit of the older peneplain; but on the margins of the region the two surfaces intersect and the older passes beneath the younger. The Paleozoic rocks lie upon the surface of the older, and the younger cuts across them (figure 1). An attempt to illustrate the manner in which, by erosional stripping back of the Paleozoic cover, portions of the old peneplain surface are exposed to view at the margins of the Adirondacks, is seen in figure 2.

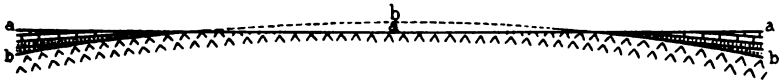


Fig. 1 Domed surface of Precambric peneplain, *b b b*, with marginal Paleozoic deposits, both truncated by late Mesozoic peneplain, *a a a*. Vertical scale much exaggerated.

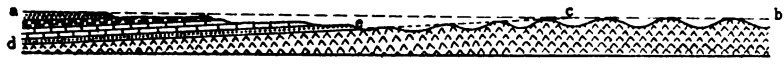


Fig. 2 Diagram in illustration of the manner of reaapearance of the old Precambric peneplain at the present surface; *a b* = late Mesozoic peneplain; *c d* = tipped surface of old peneplain, in part covered by Paleozoic rocks; from *c* to *c*, however, the Paleozoics have been recently removed by erosion, reexposing the old peneplain surface; modern erosion has cut valleys in both peneplain surfaces, but the ridge summits are remnants of these surfaces.

Since the development of the Mesozoic peneplain the highland has been again uplifted, the uplift being greatest along the eastern border. This has given the peneplain surfaces a tilt to the west. Since this uplift the present valleys of the region have been cut below the surface of the Mesozoic peneplain and, on belts of weak rocks, have become broadly developed. The entire surface of the Saratoga and Schuylerville quadrangles is below the level of the peneplain, with the possible exception of the hill summits in

Digitized by Google

the vicinity of Black lake. The uplift was accompanied by dislocations of the peneplain surface, owing to movements along the great fault planes of the region, which broke up the uniform surface into a mosaic of flat-topped blocks at varying levels. Because of this dislocation and the modifying effects of subsequent erosion, the recognition of the peneplain surface in the eastern Adirondacks is a matter of considerable difficulty. The western Adirondacks were uplifted without dislocation, and there the peneplain is easily recognized.

The Adirondack highland is a moderately rugged region with much bare rock and comparatively little good soil, and is forest-covered throughout. In winter it is tenanted by the lumberman, in summer by the tourist and the river-driver. The population is scanty and scattered. The region is strangely poor in mineral wealth. But the forest and the water power are of great value; and no less so are the invigorating climate and the charm and beauty of wood and water.

THE MOHAWK LOWLAND

Since the uplift of the Mesozoic peneplain, the weaker rocks of the region have been deeply eroded. Along belts of weak rock, valleys have been carved, the valley bottoms representing the beginning of development of a new and lower peneplain. Not far south of the Adirondacks runs a great, east-west belt of weak shales, and into them the valley of the Mohawk has been carved as a great belt of lowland between the Adirondack plateau on the north and the plateau of southern New York. Great faults cross the valley bringing up masses of more resistant rock, as at Little Falls, St Johnsville, Sprakers, Tribes Hill and Hoffmans Ferry, and in these the lower valley narrows and its walls steepen. Otherwise the valley is broad and wide.

East of Hoffmans it becomes especially wide, on approach to the region of deformed rocks of eastern New York, in which the strike of the rocks approximates a north-south direction. The belt of shale broadens northward, curving around to merge with the Hudson valley lowland.

HUDSON VALLEY LOWLAND

From Fort Edward to Poughkeepsie the Hudson occupies a broad, often very broad, valley eroded in a belt of soft shales, quite similar to the Mohawk valley. The shales are also of quite

Digitized by Google

similar character. But unlike the shale belt of the Mohawk, these shales are greatly deformed. They have been compressed, folded and faulted, and show steep dips nearly everywhere, instead of lying flat. The boundary between the two shale belts is fairly abrupt, and is readily traced across the Saratoga district. The shales of the Saratoga quadrangle are the undisturbed shales of the Mohawk belt, while the greater part of those of the Schuylerville quadrangle are the tipped shales of the Hudson valley belt. The greater part of the Schuylerville quadrangle is included in the Hudson lowland.

There are occasional harder bands in these tipped shales, bands of hard sandstone or grit and chert, whose lines of outcrop form low ridges on the otherwise level valley floor. Glacial deposits also diversify it somewhat, as they do along the Mohawk. Close to the river they have been washed away, but back from it they rise in prominent benches and widely cover the valley floor so that rock outcrops are very exceptional.

Two hilly tracts of land rise from this plain, one east of Saratoga lake, culminating between Ketchums Corners and Quaker Springs and attaining the 600 feet level; the other in the northeast corner of the Schuylerville sheet, north of the bend in the Moses kill. A landmark in the broad plain north of Fish creek is Kendrick's hill rising 200 feet above the plain.

The hilly region at the eastern edge of the Schuylerville sheet is the western margin of a plateau of somewhat higher level. This plateau is but little higher than the Hudson river plain; its base is about 400 feet above sea in the west and it rises gradually to about 600 feet across the adjoining Cambridge sheet to the eastern edge of that sheet, where another somewhat abrupt rise takes place to a higher plateau. We will call this lower plateau, which is about 10 miles wide, the Greenwich plateau. It can be traced on the east side of the Hudson across the Hoosic into Rensselaer county and south, where it lies in front of the Rensselaer plateau and has been fully described by Dale.[1] This plateau is characterized by its extremely irregular surface, as shown on the eastern edge of the Schuylerville sheet. It is covered with a great number of more or less oval hillocks, mostly but a few hundred feet high, but in many cases rising 500 feet, and in some even a thousand feet above the plain. It gradually approaches the Hudson river until at Troy

[1] Dale, T. Nelson. Geology of the Hudson Valley between the Hoosic and the Kinderhook. U. S. Geol. Surv. Bul. 242. 1904.

Digitized by Google

it forms the bluffs of the east bank of the river and thence merges into the Hudson river plain.

DRAINAGE

The two quadrangles drain entirely into the Hudson, the Schuylerville directly, the larger part of the Saratoga indirectly. The chief portion of the latter drains through Kayaderosseras creek into Saratoga lake, and thence by Fish creek into the Hudson, while the extreme northwest reaches the river by the still more indirect route of the Sacandaga.

Across the Schuylerville quadrangle flows the Hudson through the structural valley of the lowland just described. In structure this valley is the direct continuation southward of the Champlain-Wood creek valley. The Hudson enters this valley at Fort Edward, north of which there is a low divide of Pleistocene materials between the Hudson drainage and Wood creek. Between Corinth and Fort Edward the present position of the Hudson was never before occupied by a large stream, but is apparently a composite of portions of the narrow valleys of small preglacial streams. A small portion of this stretch of the river's course is seen on the two quadrangles, the remainder lying within the Glens Falls sheet. In this part of its course it shows frequent and abrupt changes in direction, abrupt variations in width, and frequent falls and rapids. At Corinth the water level is 520 feet, at Fort Edward 140 feet, and the distance is less than 12 miles in an air line, though much more following the river. This is a fall of over 30 feet to the mile.

At Corinth the river is in another structural valley of good size, which in preglacial times must have been occupied by a considerable stream. It has followed this valley for many miles through the mountains. Structurally this valley continues to the south across the Saratoga quadrangle and is now occupied by Kayaderosseras and Sturdevant creeks. It is heavily filled with Pleistocene deposits, especially at the north, and it was this depth of drift filling which turned the Hudson aside into its modern course through Glens Falls. The deeper channel of the valley is indicated on the areal map, and the valley continues on to the south past Ballston and through Ballston lake to the Mohawk at Schenectady.

In this vicinity, then, the present Hudson is occupying portions of two ancient, structural valleys, while its course from Corinth to

Digitized by Google

Fort Edward is its postglacial route of passage from the one to the other.

Aside from the river, the two principal streams of the district are Batten kill, coming into the river from the east, and the Kayaderosseras creek — Fish creek drainage from the west. This latter basin covers most of the Saratoga quadrangle and about one-third of the Schuylerville as well. Only the lower portion of Batten kill lies within the map limits, some 7 miles long following the stream, but only a little over 4 miles in an air line. In this short distance it drops over 200 feet. The larger part of this drop is made at Middle Falls and at the fall 1 mile below Middle Falls, unnamed on the map. This part of the stream's course is wholly modern and postglacial.

All the upper portion of Kayaderosseras creek lies in the deeply drift-filled, structural valley running south from Corinth. Heavy drift across the valley east of Middlegrove turns the stream aside and its course between Middlegrove and West Milton is modern and to the west of the old valley, with the chief drop at Rock City Falls. At West Milton it reenters and crosses the old valley, then turns south through Ballston in a modern course, with frequent rapids and falls. Below Ballston it flows through a shallow valley wholly in drift to Saratoga lake. Below the lake it is a sluggish stream with little fall in preexisting valleys until the big bend just below Victory Mills is reached. The final mile and a half of the stream is again in a modern channel, with a drop of nearly 100 feet.

On these three streams, because of their steep gradient, there are numerous water-power sites, all of which are occupied and in vigorous use. Few districts show as thorough utilization of power possibilities.

GLACIAL DEPOSITS

On the higher grounds of the district there is no great thickness of glacial deposit, and the topography and bedrock geology are well shown. But at the lower levels, and chiefly in the two great valleys, there is abundant and often thick drift, constituting an important element in the topography. This drift is in part glacially deposited and in part a water deposit.

MORAINES

No terminal moraine of any particular prominence lies within the map limits, though there is a considerable morainic belt running across the northern portion of the Saratoga quadrangle. But there

Digitized by Google

is a tremendous lateral moraine terrace banked up against the mountain front along the west side of the Kayaderosseras valley and a smaller but similar one along the Mt McGregor front. These would seem to have been deposited along the sides of the ice lobes which occupied these valleys during the retreat of the last ice from the region. They are overspread with sand in varying amount, deposited from streams supplied by the melting ice, which flowed along the margins of the ice lobes between the ice and the valley wall.

DRUMLINS

These are oval-shaped hills of drift, chiefly till, supposedly formed underneath a glacier near its end. There is a group of ten or a dozen such hills in the Kayaderosseras valley, grouped in a rude triangle whose apex is the large drumlin just south of Kings, on the Adirondack branch of the Delaware & Hudson Railroad, and whose base extends across southern Greenfield township into northwest Milton. Shaped by the ice, the longer axes of such hills are supposed to trend with the direction of ice movement. In this group the trend varies from north-south to south 20° west. They show prominently on the topographic map.

A group of hills of similar appearance, east of Saratoga lake, Schuylerville quadrangle, are rock hills and not drumlins at all. Harder bands in the tipped shales, either chert or sandstone, are responsible for these hills.

TERRACES

There are several broad terraces of sand and gravel within the mapped limits, chiefly the delta deposits of streams formed during the ice retreat from the region. Batten kill built a great delta in the higher water levels of the time, forming a great terrace east of the Hudson, banked up against the base of the hills, from Bald mountain southward, the larger part of it being south of the present position of the stream.

Running southwest from Gansevoort through Wilton is a tremendous sand terrace, which continues on into confluence with the similar terrace to the east and south of Saratoga Springs. The summit levels of this terrace are quite like those of the Batten kill delta. Southwest of Saratoga Springs, in Milton township, is another great sand terrace, at a somewhat higher level than the other two. In the valley south of Corinth, hemmed in between the higher grounds on each side, is a smaller sand delta, at a much higher level.

Digitized by Google

The deposits of these terraces were laid down in close proximity to the ice sheet, occasionally covering stranded blocks of ice. When this melted away, depressions were left which became occupied by ponds. Three such ponds lie in the sands south of Corinth; and Moreau pond, northwest of Gansevoort, and Lonely lake near Saratoga lake, are larger examples. Saratoga lake itself lies in an old drainage valley, and in a portion of it which was less deeply filled with drift than the remainder.

GENERAL GEOLOGY

BY H. P. CUSHING

The surface rocks of the Saratoga and Schuylerville quadrangles belong apparently to two separate geologic provinces. The rocks of the Saratoga and the western portion of the Schuylerville quadrangle are those of the Adirondack plateau and the lower Mohawk trough; those of the remainder of the Schuylerville quadrangle are deposits of more eastern troughs. The Adirondack plateau rocks are of Precambric age and comprise both sedimentary and igneous rocks. Those of the Mohawk trough are of early Paleozoic age, Cambric and Ordovicic, and contain no igneous rocks in the Saratoga region. Those of the more easterly troughs are also of early Paleozoic age, Cambric and Ordovicic. But the formational units are quite different from those of the Mohawk trough, and the two are also very unlike structurally.

Except for the cover of comparatively recent deposits of Pleistocene age there are no rocks in the region younger than the Ordovicic, with one trifling exception, and that an igneous rock. A mile north of Schuylerville, on the west bank of the Hudson, is a small knob of extrusive rock of peculiar character, which is certainly younger than the Ordovicic and in all probability very much younger.

STRUCTURE

Since their formation the rocks of the Adirondack region and the Mohawk trough have been considerably deformed. The Precambric rocks of the Adirondacks were enormously deformed in Precambric time and folded in a complex manner, while the sediments were all cut to pieces by great intrusions of igneous rock from beneath.

Besides this early deformation the rocks of the eastern Adirondacks have undergone subsequent deformation, in common with

Digitized by Google

the Paleozoic rocks of the Champlain valley. This has chiefly expressed itself in the formation of a great number of normal faults, both large and small. The Paleozoic rocks of the trough are but little folded and usually but slightly tilted, but they are cut into great slices by a series of normal faults which trend about north-northeast, and which are themselves broken by occasional cross faults. Most of these faults downthrow to the east, but at the same time the upthrow side is given a tilt to the west, forming a valley when combined with the upthrow side of the next fault to the west. Occasional faults throw to the west, with the result that a depressed structural valley called a graben is formed.

The drop from the level of the Adirondack highland to the low grounds of the Mohawk trough is produced by a series of these great faults, all throwing to the east.

Passing from the Mohawk rocks to those of the more easterly troughs, one finds a quite different kind of structures. In the first place the rocks are much more folded. The chief structures here are also faults, but instead of being nearly vertical and normal, they are quite flat and are overthrusts, along which great masses of rock have been pushed westward for miles. Unlike the Mohawk rocks, they now lie far from the area where they were originally deposited and form a jumble of overthrust masses. Their structure is exceedingly, often hopelessly, complicated.

DESCRIPTIVE GEOLOGY

BY H. P. CUSHING

The exposed rocks of the two quadrangles are of Precambric, Cambric and Ordovicic age, together with the unconsolidated deposits of Quaternary age and the small exposure of extrusive rock of unknown age north of Schuylerville.

PRECAMBRIC ROCKS

The Precambric rocks of the Adirondack region, so far as known, are comprised in an old series of sedimentary rocks, named the Grenville series, which are the oldest known rocks of the district, and in various masses of igneous rocks all of which cut the Grenville rocks intrusively and are therefore younger. The oldest of these igneous rocks is a granite called the Laurentian. Later than this came a series of intrusions, anorthosite, syenite,

Digitized by Google

granite and gabbro, in the order named. These probably represent a group of closely related intrusions not widely separated in time from one another. Much later came renewed igneous activity with intrusion of diabase (trap), found exclusively as dikes cutting all the other Precambric rocks.

Representatives of all these rock groups occur in the Saratoga region. The Grenville rocks are abundantly represented; Laurentian granite is probably present, that is to say there is abundance of a granitic rock which we regard as probably Laurentian; the second group of intrusions is represented by abundant syenite and apparently by that alone; and occasional trap dikes of large size belong to the last group.

GRENVILLE SERIES

The Grenville series in the Adirondacks exhibits an enormous thickness of limestones, quartzites and various sorts of schists. On the Saratoga quadrangle the bulk of the Grenville consists of schists, but there is also a considerable amount of quartzite. Limestone is present only as occasional thin bands in the quartzite series. A few miles farther north, however, much more limestone comes in. A considerable belt in which there is much quartzite, interbedded with thin bands of schist and limestone, contrasts so strongly with the remainder of the Grenville that we have mapped it separately. With this exception the intricate admixture of various schists absolutely defies detailed mapping.

In addition, the series is everywhere cut to pieces by a white, granitic rock of somewhat peculiar type, that we have heretofore been regarding as a Grenville sediment. The reasons for regarding it as an igneous rock will shortly appear. We have mapped separately three areas of this rock, but the mapping is vague and highly conventional. The rock is found everywhere throughout the Grenville area, inextricably mingled with the schists. In these three areas it exceeds the schists in quantity and is mapped separately to give conventional expression to our views respecting its nature and relationships. We are provisionally regarding it as Laurentian, that being the term applied to the ancient granitic rocks which, throughout Canada, the Upper Lake region and the Adirondacks, invade and cut to pieces the oldest known clastic deposits. The uncertain feature of this correlation, so far as the Adirondacks is concerned, is that the Laurentian granite, in the Lake Superior region, is older than the Lower Huronian, hence the use of the

Digitized by Google

term in the east necessitates holding either that the Grenville series is also older than the Lower Huronian, or that the Laurentian granite is younger than about Lake Superior, since the granite is certainly younger than the Grenville.

GRENVILLE SCHISTS

As has been stated, Grenville schists exist in such great variety and with such rapid alternations as to defy detailed mapping and to render detailed description laborious and profitless. The schists are everywhere intricately involved with hard, white, garnetiferous gneisses which, heretofore regarded as sediments, seem to the writer to be plainly igneous rocks. They cut the schists intrusively and develop pegmatites. In the majority of exposures they are merely injected along the foliation planes of the schist, forming injection gneisses and looking extremely like interbanded sediments. The more common of the schists are mica schists, and the prevailing Grenville combination of the quadrangle consists of the interbanded mica schist and white granite.

These mica schists vary from very weak rocks with abundant mica to much firmer ones in which mica is scant. Because of weakness, the former variety is seldom seen in outcrop, but several cuts through such schists expose them well along the Adirondack Railroad a mile north of Saratoga. The firmer varieties outcrop everywhere.

These schists are feldspar-quartz-mica combinations, and nearly everywhere contain in addition pink garnets. The mica is biotite and the bulk of the feldspar is plagioclase, oligoclase to andesine. Quartz forms in general from 10 to 25 per cent of the rock. Foliation is thorough and even.

On the one hand these mica schists grade over into amphibolites, which are heavy black gneisses composed essentially of plagioclase feldspar and hornblende, with usually black mica and pyroxene in addition; on the other hand they grade into hard, light colored feldspar-quartz gneisses, by diminution in the mica present.

The garnets seem to owe their origin to contact action of the white granite upon the schists, as will be later shown. Graphite is a frequent mineral in the schists.

The schists are in chief part metamorphosed shales, as indicated clearly by their composition and structure. They have been entirely recrystallized, injected in complex fashion by granite, and vastly changed in appearance and character. Originally they varied

Digitized by Google

somewhat, clay shales alternating with sandy shales, and these with calcareous shales. These original variations are still discernible in the schists as bands of varying character, whose chief differences from one another are in the relative proportions of the three common minerals, quartz, feldspar and mica, which compose them.

Grenville amphibolite. There is not a great quantity of amphibolite in the Grenville of the Saratoga quadrangle, and such as there is occurs mingled with the other Grenville rocks in masses of no great size. It occurs in two different ways. On the one hand it forms comparatively thin bands, so interbedded with the other Grenville rocks as to make it highly probable that it represents a band of sediment, a probable original calcareous shale. These bands often appear to grade into the general schists which are interbedded with them. On the other hand it occurs in more or less oval masses which, notwithstanding their small size, seem to cut through the other Grenville rocks, instead of being interbedded, and hence to represent igneous rocks of somewhat later age instead of contemporary sediments. The former are commonly, though not always, heavier, denser and blacker rocks than the latter. Amphibolites of both types occur abundantly in the Adirondacks, but it is by no means always possible definitely to determine to which type a given occurrence belongs, especially when the masses are as small as on this quadrangle.

Grenville quartzite. The chief belt of Grenville rocks other than schists is an east-west belt about a mile in breadth of surface outcrop, which crosses the Saratoga quadrangle through Greenfield township from just west of Kings Station to Mt Pleasant. This is not a belt of solid quartzite, but consists of numerous beds of quartzite, interbanded with various schists and with thin beds of crystalline limestone. The central part of the belt, downfaulted into the Kayaderosseras valley, is covered by younger rocks. West of Mt Pleasant it is cut out by syenite. Though occurring in thin bands elsewhere, the Grenville quartzite and limestone of the quadrangle are practically confined to this belt.

The quartzites present substantially the same varieties as are common elsewhere in the Adirondacks. There are beds of coarsely crystalline, glassy looking quartz rocks, in which quartz constitutes from 70 to 90 per cent of the rock, and the remainder is chiefly feldspar. The finer grained quartzites are usually less quartzose, though with quartz always forming 50 per cent or more of the rock. They are usually quartz-feldspar or quartz-pyroxene rocks. The latter

Digitized by Google

are less abundant about Saratoga than the former. They are often somewhat micaceous, a brown phlogopite being the usual mica. Pyrite is also a common mineral, and the pyritiferous quartzites, on weathered surface, have the pyrite weathered out and replaced by a brown limonite stain.

Much of the quartzite contains graphite sparingly. There is a thickness of at least 100 feet that contains it in sufficient quantity so that it has been worked for graphite at two different localities on the quadrangle, 1 mile southwest of Kings Station and 2 miles west of Porter Corners. The rock is quite similar at the two places, being granular and considerably altered. It is interbedded with quartzites and quartzose mica schists and is itself a graphitic quartz schist. At the Porter Corners locality the rock is a quartz-feldspar combination, about 50 per cent quartz, 40 per cent feldspar, and the remainder graphite and mica. In the special bed worked there is but little mica and nearly 10 per cent of graphite. Above and below more mica comes in. The feldspar is very badly altered.

At the Kings Station locality the rock is so similar as strongly to suggest the identity of the horizon. On first appearance, the rock seems richer in graphite than at Porter Corners, and may be so; but it certainly contains more mica than that, a disadvantage from the standpoint of successful working. The rock in both places is very similar to that which has been worked for years about Hague; and though it is quite possible that there may be more than one horizon of such graphitic quartzite in the Grenville, it seems more reasonable to assume but one, in default of definite evidence to the contrary.

Grenville limestone. But two beds of limestone were seen in the Grenville of the quadrangle, one noted only at the dam of the Kings Station graphite mill, the other in two localities, about a mile apart along the strike, between 3 and 4 miles west of north of Kings Station. Each is about 10 feet thick, impure, and closely associated with heavy, black amphibolites, which are very common border rocks to the limestones in the Adirondacks and were originally very impure limestones.

The limestone of these two beds is far from pure, the calcite constituting not over 50 per cent of the rock. The most common of the other constituents is quartz, but scapolite, pyroxene, phlogopite, graphite and titanite are also present. Much of the rock is fine grained and of a gray tint, instead of being the usual, coarsely crystalline, white marble of the region.

Digitized by Google

PRECAMBRIC IGNEOUS ROCKS

General statement. In order of age the Precambric igneous rocks of the quadrangles are the Laurentian (?) granite, the syenite, and the trap (diabase) dikes. There are in addition very small and occasional masses of amphibolite which are probably original gabbros and younger than the syenite, but they merit only passing notice because of their small bulk and problematic character.

Laurentian (?) granite. A previous statement makes reference to a white, granitic rock, intricately involved with the Grenville schists, which is a common constituent of the Grenville throughout the southern Adirondacks and which we have heretofore regarded as a Grenville rock. Thus Cushing, reporting upon similar rocks from the Little Falls quadrangle, classes them as Grenville.[1] Kemp and Hill describe the similar rock from the "Noses" in the Mohawk valley as a Grenville sediment.[2] The problem is an involved one since the granite is seldom pure but has everywhere taken in a considerable amount of the adjacent Grenville rocks, giving rise to a mixed rock composed of varying amounts of granite and schist. The recognition of pegmatitic phases of the rock threw the first doubt upon its sedimentary character; afterwards it came to be recognized that the granite itself, as well as its pegmatites, was intrusive as regards the schists. The chemical analysis eventually settled the question.

The granite is a difficult rock to describe because it is nearly everywhere so involved with the schists, or with material from the schists, as to make rock free from such contamination difficult of recognition. The mica is the most obvious of the contributions from the schist, which is certainly much richer in that mineral than the original granite. Hence arises a tendency to infer that those portions of the granite freest from mica are those least contaminated. Such portions show a very white rock composed of white feldspar and quartz and a very little black mica (biotite). In addition are small amounts of apatite, titanite, zircon, and magnetite. Pink garnets are always present but are not regarded as original minerals of the rock. They are most abundant in the schists which have been thoroughly impregnated with granite, and have in most cases resulted from corrosive interaction between the minerals of the two rocks. In other words, most of the garnet is

[1] N. Y. State Mus. Bul. 77, p. 17–19.

[2] N. Y. State Geol. 19th Ann. Rep't p. 132–135.

Digitized by Google

a contact mineral. Its occurrence in the pegmatites, however, suggests caution in ascribing it all to such a source.

The granite is chiefly found thoroughly interbanded with the schists, injected into them parallel with their foliation, forming apparent beds of hard, white gneiss which alternate with those of schist. The beds vary in thickness from a few feet to many. It is only in exceptional cases that the granite can be seen to cut across the schist foliation. It is quite otherwise with the pegmatite dikes from the granite which cut it and the schists in all directions, and seldom follow the foliation. In the three small areas which we have mapped as granite, the rock is full of schist, ranging from mere films to bands many feet thick. These are all thought to be stretched inclusions, though it is seldom possible to demonstrate this. The bordering areas mapped as schist are likewise full of granite and pegmatite dikes, so that the mapping is highly conventional and merely roughly distinguishes areas in which granite is in excess from those in which the schist predominates. But the relations are much less simple and obvious than in the Thousand Islands region where what we regard as similar relations between Grenville and granite obtain. In passing across the Adirondacks from west to east the Precambric rocks show a steady increase in complexity because of ever more severe metamorphism, until eventually, in the extreme east, the whole series has been so enormously compressed and stretched that it is no longer easy to recognize inclusions of sediments in igneous rocks, or dikes of igneous rocks in sediments, owing to the apparent interbanding.

There has also been much intermediate rock produced by a thorough interpenetration of the schist by the granite. The exposed granite masses are small, and we have not noted the evidence of the actual digestion of schist by granite, with production of rock of intermediate character, such as may be seen in the cases of the larger batholiths of Laurentian granite. There has been much injection of schist by granite, however, both along the foliation planes with production of injection gneiss, and also of the mosaic type in which the granite minutely penetrates the schist everywhere. In many bands of this type an enormous amount of garnet has developed.

The pegmatites. It was the abundant dikes of white granite pegmatite that first suggested the igneous nature of the white gneiss and furnishes the chief evidence for it, aside from the chemical composition. They cut through the granite everywhere and also

Digitized by Google

through the surrounding schists. Except for being usually more quartzose they are quite like the granite in mineralogy, coarsely crystalline aggregates of quartz and white feldspars (microperthite and oligoclase) with some biotite and often garnets. The schists just to the north of Saratoga, as shown along the Adirondack Railroad and along the north margin of Highland park, are full of these dikes; and a little farther north, along the fault scarp, the granite shows well and accessibly and has been quarried somewhat. In addition to the usual minerals these dikes show here and there other and rarer minerals. The old chrysoberyl locality, just to the north of Saratoga, is on one of these dikes in the schist. In this a lot of black tourmaline has developed, so that the pegmatite is a quartz-feldspar-tourmaline-garnet rock, in which frequent nests of chrysoberyl crystals occur. The dike cuts a hard mica gneiss and is about 3 feet wide at the old pit. One and one-half miles south of South Corinth is another old mineral pit on a pegmatite vein in schists, which furnished fine black tourmaline and rose quartz.

Mixed rock. With the exception of the pegmatites practically all the granite is contaminated with schist. We interpret this contamination as resulting from the shredding and dispersion of the schist inclusions in the granite under conditions of extreme pressure and metamorphism. All gradations occur between bands of schist somewhat impregnated by granite and granite that seems normal except for the fact that it may be somewhat more micaceous than it should be. This introduces an element of uncertainty in the attempt to investigate the granite chemically.

Chemical composition. The material chosen for analysis was obtained from the quarry in the granite on the face of the fault scarp 2 miles north of Saratoga, and was chosen because it was fresh and because contamination with schist seemed slight, if any. The thin section showed quartz, about 25 per cent, feldspars about equally divided between oligoclase on the one hand and microcline and microperthite on the other, about 70 per cent, and the remainder biotite, except for a few small zircons and a trifle of apatite and titanite. The hand specimen shows occasional garnets, none of which got into the thin section. The rock shows a rude banding due to variations in the amount of mica, suggesting a trifle of shredded schist in the more micaceous bands, but not enough to impair materially the value of Doctor Morley's analysis.

Digitized by Google

	1	2	3	4	5
SiO_2	72.41	73.33	73.10	70.13	1.207
Al_2O_3	13.85	13.55	14.29	15.47	.136
Fe_2O_3	1.13	.58	1.04	1.52	.007
FeO	1.57	1.53	1.04	1.05	.022
MgO	.45	.45	.53	.85	.011
CaO	1.54	1.66	1.18	1.60	.028
Na_2O	4.31	5.01	3.08	3.72	.069
K_2O	3.68	3.12	5.36	4.39	.040
H_2O+	.41	.45	.54	.48	.....
H_2O-	.....	.....	.07	.01	.....
TiO_2	.44	.17	.18	.30	.005
P_2O_5	.07	.....	.03	.....	.0005
Cl	.....	.....	.03	.05	.....
F	.01	.....	.02	.09	.0005
S	.05	.....	.02	.07	.....
MnO	.33	.04	.07	.08	.004
BaO	.03	.....	.....	.05	.....
	100.28	99.89	100.58	99.86	

1 White granite (Laurentian?) from 2 miles north of Saratoga. E. W. Morley, analyst.

2 Laurentian granite gneiss from the Methuen bathylith of central Ontario. F. D. Adams, Jour. Geol., 17:17.

3 Laurentian granite gneiss of the Alexandria bathylith. E. W. Morley, analyst, N. Y. State Mus. Bul. 145, p. 176.

4 Laurentian granite gneiss of the Antwerp bathylith of northwestern New York, granite with slight amphibolite contamination. E. W. Morley, analyst, N. Y. State Mus. Bul. 145, p. 176.

5 Molecular ratios of analysis no. 1.

A comparison of the four analyses given brings out at a glance the practical identity of the Saratoga rock with those of Ontario and northwestern New York. They differ only in the alkali ratio, soda exceeding potash in the rock from Ontario, and the reverse being true in that from northwestern New York. In this respect the Saratoga rock is more like that from Ontario, though occupying an intermediate position. That this would be the case was indicated in the thin section, oligoclase being much more abundant and microperthite correspondingly less so than in the rocks from the Thousand Islands region. We regard the chemical evidence as strongly corroborative of the impression gained in the field regarding the igneous nature of this white gneiss.

Digitized by Google

The norm of the rock of analysis 1 is as follows:

Orthoclase	22.24		Class 1, persalane
Albite	36.15		
Anorthite	6.95	94.34	Order 4, britannare
Quartz	28.80		
Corundum	0.20		Rang 2, toscanase
Hypersthene	2.60		Subrang 4, lassenose
Magnetite	1.62		
Ilmenite	0.76	5.15	
Apatite	0.17		$K_2O : Na_2O :: 3 : 5.2$

The northwestern New York granites belong in subrang 3, toscanose, while the Ontarian rock is a distinct lassenose. The Saratoga rock is on the border between the two subrangs as the alkali ratio shows.

The rock differs considerably in appearance from the usual Laurentian granite of Canada and northern New York, the chief differences being the white color and the content of pink garnet. In the Thousand Islands region we have shown that the red Laurentian granites have their red feldspars bleached to white in the vicinity of Grenville limestones.[1] We have seen similar bleached granites in Ontario in like situation. About Saratoga the granite masses are small and suggest that erosion here is just beginning to uncover a granite bathylith and has reached only a few of the higher protuberances, full of included rock masses. This might suggest that the granite would run into red rock in depth, but the matter is not urged since the chief inclosing rocks are schists which are poor in lime.

Because it gives rise to pegmatites and has the composition of a granite, this rock is regarded as igneous. It is further regarded as Laurentian for two reasons: first, because it is distinctly older than the syenite which cuts it intrusively just as it cuts the Grenville; and second, because it also shows its great age by the intricate manner in which it is involved with the Grenville and has been metamorphosed in common with it. In the latter respect it furnishes a strong contrast with the Laurentian granites of northwestern New York, whose relations with the Grenville are much less involved and more obvious. This contrast is to be attributed to the fact that the Precambric rocks of the Adirondacks show a

[1] N. Y. State Mus. Bul. 145, p. 46-7, 177-180.

Digitized by Google

progressive increase in amount of metamorphism from west to east, so that, when the eastern border is reached, the relations of the rock groups to one another have become much disguised and difficult to decipher. If this white rock be really an igneous granite, then its relations to the Grenville are apparently just those which are diagnostic of the Laurentian in western New York and in Ontario. The apparently confused commingling of the two rocks, the apparent interbedding, and the abundant development of pink garnet both in the schists and in the intrusive, are the expression of the greater severity of metamorphism.

The syenite. The surface rocks of much of the Adirondack region are intrusive igneous rocks of early Precambric age, but younger than the Grenville and the Laurentian. There are four groups of these rocks — anorthosite, syenite, gabbro and granite — named in order of age. The first two occur in much greater volume than the last two. In distribution, the anorthosite differs from the syenite in occuring chiefly in a single great bathylitic mass whose area at the present-day surface is about 1500 square miles in the eastern and central Adirondacks. There are small outlying masses to be sure, but neither abundant enough nor large enough materially to qualify the general statement. The southern edge of this mass is well north of the Saratoga quadrangle so that, except for an occasional glacial boulder, the rock is not found here.

The syenite contrasts quite sharply with the anorthosite in distribution. Instead of appearing in one huge mass it forms many small ones; instead of being an abundant rock in part of the region and wholly lacking in the remainder, it is found everywhere throughout the Adirondacks. Every detailed map of part of the region shows it present; and we know also that it is abundantly present in the remainder which has been covered merely by reconnaissance work. Because of this scattered distribution we are wholly unable as yet to give any estimate of any value concerning the area which the rock occupies; we can, however, now say that syenite is the surface rock of a much greater area in the Adirondacks than that occupied by anorthosite, large as the latter is, and that the area of syenite is a notable one when compared with any other known area the world over.

There are three main areas of syenite within the mapped limits. The largest is the one which forms the main mass of the Mt McGregor range and its back country. The modern gorge of the

Digitized by Google

Hudson cuts through this mass, some quarrying has been done in it to furnish masonry for Spiers dam, and hence the general exhibit of the rock along the river is the best to be found within the quadrangles. Up the hill west of Corinth is the southern half to two-thirds of another mass running north on to the Luzerne sheet; and the third area runs west from Lake Desolation and Mt Pleasant and its western extension may be seen on the map of the Broadalbin quadrangle.[1] It should be clearly understood that the boundaries between the syenite and the Grenville, as drawn on the maps, are of the most vague description. A multitude of dikes run out from the syenite into the Grenville; the syenite is full of inclusions of Grenville and the whole combination has been much deformed. There is plenty of syenite outside the areas mapped as such and there is much Grenville within the areas mapped as syenite. The best that can be done on maps of this scale is to endeavor to map as syenite, areas in which this rock constitutes more than 50 per cent of the whole, and as Grenville those in which the syenite constitutes less than 50 per cent.

The syenites have been described in detail, with chemical analyses in so many of the New York State Museum bulletins that it seems superfluous to repeat the discussion here.[2] As shown on the quadrangle, they are usually greenish gray rocks, sometimes blotched with red and grading into varieties richer in quartz and wholly red. The rock is thoroughly gneissoid. The most interesting thing about it is the way in which it uniformly runs over into coarsely porphyritic varieties at the margins and in the dikes of syenite in the Grenville. The porphyritic crystals, usually called augen, are often large, reaching a length of 2 inches, while those of an inch in length are very common; the feldspar of these augen is usually red, the augen are aligned parallel to the foliation, and in many cases are partly or wholly crushed or granulated. In the body of the rock, mica has developed in quantity and the resemblance to a metamorphosed conglomerate is strong. The rock is considerably more quartzose and acid than the main body of the syenite.

In the description of the Alexandria syenite of the Alexandria quadrangle, a similar porphyritic, marginal phase of the rock was described, but some doubt was expressed as to whether it was in

[1] W. J. Miller, map accompanying N. Y. State Mus. Bul. 153.

[2] Bul. 95, p. 312–40; Bul. 115, p.512–25; Bul. 138, p. 44–52; Bul. 145, p. 182–84; Bul. 153, p. 14–21.

Digitized by Google

reality a marginal part of the same intrusion, or a separate intrusion.[1] The porphyritic border phases of the rock as they occur about Saratoga, where the relation to the main rock is certain, are so precisely like this porphyritic rock from Alexandria as to leave no doubt in our mind that this is also a border phase of the syenite intrusion. Such border phases of the rock, of porphyritic nature, are proving a quite normal feature of the syenite of the region.

The rock here varies about as it does elsewhere except that the more basic phases are lacking. Granitic varieties, however, are abundant. This seems to us likely due to the fact that the surrounding rocks in the quadrangle are mostly of siliceous nature. Much more than in the case of the other intrusives of the region there is found for the syenite a usual relation between the nature of its border phase and the character of the neighboring rock; such a relation as indicated by Kemp for the occurrences of the Elizabethtown quadrangle, and by the writer for the Long Lake quadrangle.[2]

But one variety of syenite on the quadrangle seems sufficiently novel to merit special notice. In the quarry by the Hudson near Spiers dam, is a very gneissoid dark green variety of syenite, one of the many varieties occurring there, which is really not a syenite at all, but diorite, 80 per cent of its feldspar being andesine (about Ab_3An_2). Pyroxene, hornblende, biotite, magnetite, apatite and zircon form about 15 per cent of the rock, some 7 per cent is quartz, and the remainder feldspar. The excellent exhibit of the rock shown in the quarry shows rapid and great range in composition, bands of granite, syenite and diorite appearing. All are plainly varieties of the one rock type. The material is almost precisely like the syenite at Little Falls in appearance and in variation, except that at Little Falls the variation between extreme types is not usually so rapid. In these very gneissoid syenites of the east, garnet is a more common mineral than in the mid-Adirondacks or on the west. There it is usually confined to the basic, border phases, or to the narrow dikes, whereas here it comes quite frequently as a constituent of the normal and the acid varieties.

Diabase dikes of late Precambric age. Nearly everywhere in the Adirondacks all the other Precambric rocks are found cut by

[1] N. Y. State Mus. Bul. 145, p. 39–40, 182–84.

[2] N. Y. State Mus. Bul. 138, p. 81; N. Y. State Mus. Mul. 115, p. 478–79.

Digitized by Google

dikes of unmetamorphosed, igneous rock. Their greater youth is shown by the fact that they cut all the other rocks. As all the other rocks have been more or less metamorphosed, and these have not, they are likely considerably younger. They are found in all parts of the region but most abundantly in Clinton county, on the extreme northeast, whence they diminish in number to the south and west. In the central and western Adirondacks they are comparatively scarce. On the extreme northwest, in the Thousand Islands region, they become again abundant. They are older than the Potsdam sandstone, the oldest Paleozoic rock of the region, and hence are of age intermediate between it and the other Precambric rocks, and likely of late Precambric age.

There are two chief varieties of these rocks: heavy, black traps, and less dense syenite rocks of red color. The latter have been so far found only in Clinton county, but the trap dikes range throughout the region. They are not particularly abundant in the Saratoga region, but those that do occur make up for their infrequency by their size. The usual trap dikes of the region range from 1 foot to 30 feet in thickness. Most of those near Saratoga are from 50 to 100 feet thick, and we have traced some of them for several miles. Thus the dike numbered 1 upon the Saratoga quadrangle, the one quarried for road metal north of the village, can be followed foot by foot for 2 miles north and south of the quarry, with an average width of from 75 to 100 feet. To the north it runs into low, swampy ground for 2 miles but beyond that and precisely on the trend of this dike we have repeatedly found a huge dike of the same width, for an additional distance of 7 miles more, which we confidently assume to be the same dike. Both to the east and west of this big dike are others which have been traced for several miles, and are 50 feet or more in width.

These are all ordinary diabases. Olivine has not been identified with certainty in any of them. They are labradorite, augite, magnetite rocks with good ophitic structure. All are considerably altered. It is exceptional to find the augite in fresh condition, and much of the feldspar is also altered. In this respect the dikes show sharp contrast with those of the northern Adirondacks where the larger number of the dikes are very fresh. This we attribute to the more vigorous glacial erosion on the north.

Digitized by Google

A table of analyses of Adirondack diabases has been recently published by Kemp, to which reference may be made by such as are interested in this subject.[1]

STRUCTURES OF THE PRECAMBRIC ROCKS

Foliation. The foliation or cleavage, the most conspicuous structure of the Precambric rocks, is found in sediments and igneous rocks alike, the trap dikes excepted. But the sediments are better foliated than the igneous rocks. The foliation of the Grenville rocks of the Saratoga region is parallel to the bedding, so that the directions of the two are equivalent. This seems to be the general relation of the two in the Adirondacks, as suggested years ago by Van Hise.[2]

The foliation strike over much of the Saratoga quadrangle is nearly east-west, and the dips are to the south and rather flat, seldom reaching 45°. The strike swerves to the northwest in the northeast portion of the quadrangle, and to the northeast in the northwest portion, though the dips remain to the south. This is not in accord with the usual direction in the Adirondacks where the prevailing strikes are northeast. As elsewhere a great monocline of the rocks is suggested; and, as elsewhere, this makes a Grenville succession of enormous thickness, so thick as to suggest caution in interpretation of the structure and as to emphasize the probability of the alternative suggestion that the rocks are closely pinched and folded, in a series of closed, overturned folds.

Faults. The great faults of the district are of much later date than the Precambric, and dislocate Precambric and Paleozoic rocks alike. But here, as elsewhere in the region, small faults are noted in the Precambric rocks of such character that they seem surely of Precambric age. We have found as yet no certain evidence of large faults of this early date.

PALEOZOIC ROCKS OF THE WESTERN TROUGH

BY H. P. CUSHING

The terms eastern and western troughs as used in this report have no significance other than convenience in description, and imply merely the relative positions of two contrasted sets of

[1] N. Y. State Mus. Bul. 138, p. 60-61.

[2] U. S. Geol. Surv. 16th Ann. Rep't, pt 1, p. 773.

Digitized by Google

Paleozoic formations. The western trough, which has been called the Chazy basin, was a subsiding trough which repeatedly was submerged beneath sea level during the early Paleozoic and received marine deposits, whose uneroded remnants still lie in comparatively undisturbed condition where they were deposited. In one or more troughs which lay farther to the east and were mostly quite separate from the Chazy basin, early Paleozoic deposits were also formed. These have since been greatly folded and faulted, and bodily overthrust to the west from their original position, upon the rocks of the Chazy basin. For convenience we here refer to them as the deposits of the eastern trough, without thereby meaning in any way to indicate that we necessarily regard them as deposits of an original single trough, rather than as of more than one. These rocks do not now lie where they were originally deposited and they are much more disturbed and folded than the rocks of the western trough.

The formations of the western trough, in order of age, are the Potsdam sandstone, Theresa formation, Hoyt limestone, Little Falls dolomite, Black River limestones (chiefly the Amsterdam limestone), basal Trenton shale and limestone (Glens Falls limestone) and Canajoharie shale. All these, with the exception of the Trenton shale and limestone, appear upon the map.

Surface upon which the western basin rocks were deposited. The old surface of Precambric rocks, upon which the basal portion of the Paleozoic deposits rests in New York, has been shown by several observers to be an uneven surface, but yet not excessively uneven. The data are most easily obtainable on the west, since there the rocks are much less disturbed than on the east. On the southwest both Miller and Cushing have shown that this surface was exceedingly smooth, almost plane, with only a few scattered hillocks rising a few feet above the general level.[1] None have been observed rising higher than 50 feet above this level. On the northwest this surface is far less smooth, and consists of rapidly alternating elevations and depressions, with maximum differences of some 125 feet of altitude. The surface consists chiefly of slopes, and but little of it is flat.[2]

On the southeast, in the Saratoga region, the surface seems much as on the northwest. For the Broadalbin quadrangle Miller reports

[1] N. Y. State Mus. Bul. 126, p. 35; N. Y. State Mus. Bul. 77, p. 59–62.
[2] N. Y. State Mus. Bul. 145, p. 54–60.

Digitized by Google

similar results.[1] Contacts are few on the Saratoga quadrangle, but to the north of the village the basal Potsdam conditions are well shown for a distance of 4 miles along the Potsdam margin; and for a mile along the Hudson just below Corinth exposures of this horizon are excellent. The Precambric surface on which the Potsdam rests is irregular. The more resistant bands of the Grenville and the igneous rocks stand above the mean level, as hillocks or ridges, while the weaker rocks are worn away to valleys or basins below mean level. Potsdam deposition began in the depressions, and as the sand accumulated it finally overtopped the elevations. There are differences of level of at least 75 feet, and probably more.

Assuming that the conditions of this surface on the northwest and the southeast (Thousand Islands and Saratoga regions) are substantially the same, as the evidence indicates, and that the surface on the southwest (Little Falls–Remsen) is much smoother, it would seem probable that in the opposite direction, on the northeast, it should be rougher. In that direction we lack the detailed work which might render the matter certain and can merely state that the impression given us by our reconnaissance work on the northeast is that it *is* rougher. We have seen Precambric hills which project up into the Potsdam to the distance of 200 feet. From the data at hand we therefore conclude that the Precambric surface under the Potsdam is least smooth on the northeast (Clinton county), and that it steadily increases in smoothness toward the southwest. The northwest and the southeast are about equidistant from these and should be expected to show about equal character of surface, as they do.

CAMBRIC PERIOD

General statement. The formations of Cambric age belonging to the western basin and found within the mapped district, are the Potsdam, Theresa and Little Falls formations, the Potsdam a sandstone, the Theresa a series of passage beds of alternating sandstone and limestone or dolomite, and the Little Falls a dolomite formation. Between the Theresa and Little Falls in the near vicinity of Saratoga is a more calcareous formation which we call the Hoyt limestone, which is probably best regarded as an upper member of the Theresa formation.

According to prevailing present-day classification, these formations are of Upper Cambric age. They also belong in the new system, Ozarkic, which Ulrich is proposing to establish between

[1] N. Y. State Mus. Bul. 153, p. 50–52.

Digitized by Google

the Cambric and Ordovicic of former classifications. Whether the Ozarkic is ultimately given the rank of a system or is regarded simply as a series forming the uppermost division of the Cambric, does not concern us here; but rather the fact that the above-listed formations are of Ozarkic age.

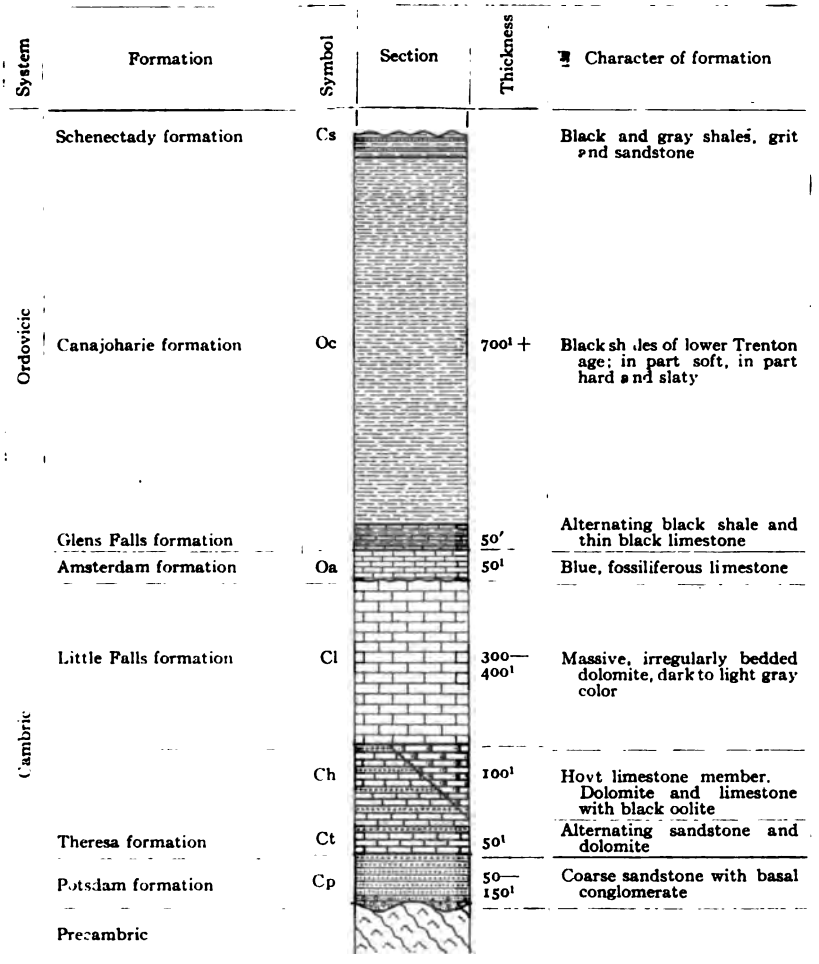


Fig. 3 Generalized columnar section of the rocks of the Saratoga quadrangle, and of the western portion of the Schuylerville quadrangle.

Digitized by Google

POTSDAM SANDSTONE

After an enormously long period of existence as a land area, whose duration comprised all the latter portion of Precambric time and most of the Cambric as well, and whose history is recorded in erosion of the Precambric rocks, the eastern margin of the Adirondacks became depressed and deposits commenced to accumulate upon its surface. Thus began the formation of the Potsdam sandstone.

The deposit began on the northeast and extended both west and south, accumulating in sinking troughs along the line of the Champlain and St Lawrence valleys. It is thickest in Clinton county, where the thickness is an unknown amount in excess of 1000 feet and where the lower beds are unlike those shown elsewhere. These beds are coarse conglomerates, feldspathic sandstones and ferruginous, shaly sandstones, wholly without fossils and apparently deposited above sea level. They are followed above by purer, quartz sandstones, white, gray, yellow, brown or red in color, mostly very thoroughly cemented and resistant rocks. Above come less firm, somewhat calcareous sandstones, forming the upper part of the formation. In this upper division and in the upper part of the preceding division a scant fauna appears which shows that this portion of the formation is marine.

It is only this upper division of the formation which is found in Saratoga county. The thickness here does not average in excess of 100 feet, ranging from 50 to 150 feet, the variations being chiefly due to the irregularity of the Precambric surface upon which it was deposited. There is usually found a few feet of basal conglomerate, seldom very coarse, above which the formation is unbroken sandstone, the lower half siliceous, the upper calcareous, in which many of the beds weather to an ochreous rotten stone. No fossils were seen by us in the formation on the Saratoga quadrangle, though Miller found Lingulepis acuminata in it on the adjacent Broadalbin quadrangle.

About Saratoga the most extensive exposures of the formation are those north of the village in Greenfield township. It is also thinly exposed at Corinth. The best continuous section is exposed along a small branch of Glowegee creek, a mile south of East Galway. At the base of the section the creek cuts down into the Precambric, exposing a small outlier of this formation. Above this a continuous section 200 feet thick is exposed. The lower 50 feet is chiefly sandstone, with occasional beds of calcareous sandstone; in

Digitized by Google

the next 50 feet sandstone and calcareous sandstone alternate, with an occasional bed of blue, sandy dolomite in addition. The upper 100 feet consists of alternations of all three. This we definitely assign to the Theresa formation. The lower 100 feet we assign to the Potsdam, notwithstanding the presence of an occasional dolomite bed. There is never any sharp boundary between the two formations.

THERESA FORMATION

Everywhere in New York where the Potsdam sandstone occurs, it is united with the formation next above, usually a dolomite formation, by a series of intermediate or passage beds which consist of alternating sandstone, calcareous sandstone and dolomite. These passage beds differ from the sandstone beneath and the dolomite above, are sufficiently thick to require mapping as a separate formation, as such require a name, and we are calling them the Theresa formation.[1] The sandstone is in excess in the lower part of the formation, and the dolomite in the upper. Deposition was apparently continuous but physical conditions slowly changed, the sand supply from the Adirondack land slowly diminishing and finally being entirely cut off. Because of this it is impossible sharply to delimit the formation, either at base or summit. In what we here class as upper Potsdam there is an occasional bed of dolomite, and a few stray beds of sandstone run well up into the overlying dolomite formation. Nevertheless there is a sufficient thickness of mingled sandstone and dolomite, about which there could be no possible difference of opinion, to justify its separateness as a formation.

In the general region the Theresa formation has a thickness of from 150 to 200 feet. Thus Miller gives its thickness as 200 feet on the Broadalbin quadrangle, while our measured sections at Whitehall and at Ticonderoga show a thickness of at least 150 feet. There is at least 150 feet of it in the section south of East Galway, on the Saratoga quadrangle, and the full thickness is not there exposed. In all these localities the formation consists of alternating beds of hard, vitreous sandstone, weak calcareous sandstone and sandy blue dolomite, with *Lingulella acuminata* as its most abundant and characteristic fossil.

West and northwest of Saratoga, in Greenfield township, the section differs. Instead of a thickness of 150 to 200 feet, the

[1] N. Y. State Mus. Bul. 145, p. 64–66.

Digitized by Google

Theresa formation is only 50 to 75 feet thick and is overlaid by a limestone formation, some 100 feet thick, which contains but little interbedded sandstone and is quite fossiliferous. This seems to us on the horizon of the upper portion of the Theresa of the sections north and west, and we therefore classify it as a member of the Theresa formation.

The rock cuts along the Adirondack Railroad, northwest of Saratoga, together with quarries to the south of the railroad, furnish us with the best section of this phase of the Theresa formation and of the Potsdam beneath. The section has already been published, and is here reproduced.[1]

		FEET	INCHES
22	Rocks concealed between two railroad cuts; boundary between Theresa and Hoyt limestone member in the interval; thickness about	20	....
21	Rotten, brown, calcareous sandstone; blue when fresh	....	8
20	Hard, vitreous, light colored sandstone, banded with narrow streaks of darker, calcareous sandstone	2	4
19	Thin bedded, blue, calcareous sandstone, weathering brownish	....	9
18	Blue black, oolitic dolomite, frequent rounded quartz grains, many small drusy cavities	1	3
17	Blue, calcareous sandstone, weathering light colored, upper portion shaly	1	8
16	Hard, light colored, vitreous sandstone	1	6
15	Thin bedded, calcareous sandstone, somewhat oolitic, blue when fresh but rapidly weathering brown, mottled and crumbly, many drusy cavities with calcite and quartz crystals; abundant trilobite fragments, the lowest zone of these so far discovered in the Saratoga region	1	3
14	Light colored, vitreous sandstone	2	5
13	Bluish, nodular, finely crystalline dolomite, with a slight amount of calcite cement, shaly at base and summit, frequent nodules of crystalline calcite; holds Lingulepis acuminata	2	3

[1] N. Y. State Mus. Bul. 140, p. 111–12.

Digitized by Google

Plate 1

H. P. Cushing, photo, 1910

Alternating sandstone and dolomite of Theresa formation in railroad cut, 3 miles west-northwest of Saratoga. The outstretched hand is resting on the trilobite layer, no. 15 of the section. Beds 12 to 17 are shown in the view.

Digitized by Google

Digitized by Google

		FEET	INCHES
12	Light colored, vitreous sandstone.....	1	3
11	Gray, banded sandstone, slightly calcareous.....	3	9
10	Alternating calcareous sandstone and crystalline dolomite of blue gray color, large nodules of crystalline calcite in the latter; base of cut.....	3	....
9	Concealed between this and next cut east; arbitrary boundary between Theresa and Potsdam in the interval; about.....	30	....
8	Hard, vitreous, light colored sandstone with darker calcareous sandstone above and below..	1	8
7	Concealed to brook exposures next east; about...	30	....
6	Light colored, vitreous sandstone, with alternating layers of darker, calcareous sandstone which weather rapidly	30	....
5	Light colored, vitreous sandstone.....	15	....
4	Concealed.....	4	....
3	Light colored, vitreous sandstone.....	2	....
2	Concealed.....	4	....
1	Conglomerate, increasing in coarseness downward and reaching nearly to base of formation.....	10	....

Numbers 1 to 8 are regarded as constituting the Potsdam though there is some question about the classification of 7 and 8, which may be Theresa. If they are regarded as Potsdam, that formation has a thickness of 96 feet, 8 inches in the section, with the base not reached, though it can not be more than a few feet away. Above is a thickness of 52 feet of beds which are certainly to be classed as Theresa, and occasional beds of sandstone run still higher.

The State road out of Saratoga toward Corinth crosses the Adirondack Railroad in a low depression between two rock cuts. The easterly one of these is the one in which the upper part of the above section was measured, nos. 10 to 21. It is the most accessible locality within the district about Saratoga where the Theresa formation is well shown. A photograph of the rock wall of the cut is shown in plate 1, the extended hand resting on the fossiliferous layer, no. 15 of the section. From this we obtained species of Ptychoparia and Agraulos which are specifically different from the forms found in the Hoyt limestone above. The species collected here were, in addition to Lingulella

Digitized by Google

(Lingulepis) acuminata, Agraulos sp. nov.[1] and Ptychoparia matheri Walcott.

HOYT LIMESTONE MEMBER

In 1879 Dr C. D. Walcott first described an Upper Cambric fauna from limestones of that age in the vicinity of Saratoga, and made frequent reference to the same fauna and beds in subsequent publications.[2] In 1899 Clarke and Schuchert first assigned a name to this formation, calling it the Greenfield limestone.[3] This name, however, was preoccupied having been previously assigned to a limestone of Siluric (Monroe) age, in central Ohio. A new name had therefore to be assigned, and yet no suitable one seemed forthcoming. The known exposures of the formation are all in Greenfield township, and the villages in the township all bear the name of Greenfield, in so far as they are located on the formation. There are no good exposures of the formation along any watercourse whose name could be utilized. The name Saratogan was preoccupied. Under the circumstances there seemed no alternative but to apply to the formation the name of the quarry at which it is best and most fully shown (plate 2). The name of the quarry has already appeared in geologic literature, in papers by Hall, Walcott and Prosser.[4] Unfortunately the farm has changed hands and the quarry is no longer locally known as the Hoyt quarry. But no other name suggests itself as suitable, and we are therefore proposing the name Hoyt limestone for the formation, at the same time indicating the location of the quarry upon the geologic map.

In an earlier paper by Ulrich and Cushing this Hoyt limestone was made a basal member of the Little Falls dolomite, the next formation above.[5] More strictly, however, it seems a phase of the upper portion of the Theresa formation, the thickness of the Theresa and Hoyt together, in the vicinity of Saratoga, about equaling the thickness of the Theresa alone north and west of Saratoga;

[1] Regarding this Dr C. D. Walcott writes Doctor Ruedemann this form is "very closely related, if not identical with a species of Agraulos which I have marked as a new species from the upper beds of the St Croix sandstone of Wisconsin."

[2] N. Y. State Mus. Nat. Hist. 32d Ann. Rep't, p. 129–31; U. S. Geol. Surv. Bul. 81, p. 346–47.

[3] Science, December 15, 1899.

[4] N. Y. State Mus. Nat. Hist. 36th Ann. Rep't, pl. 6, description; Science, 1884, 3:137; N. Y. State Mus. Bul. 34, p. 478–79.

[5] N. Y. State Mus. Bul. 140, p. 129.

Digitized by Google

Plate 2

H. P. Cushing, photo, 1910

Hoyt limestone at Hoyt quarry, showing the lower 16 feet of the 25 feet of the quarry section. The massive central bed, nearly 5 feet thick, is noteworthy.

Digitized by Google

Digitized by Google

while the Little Falls dolomite at Saratoga has about the same thickness as it has to the west and north. Miller has already made a similar suggestion.[1]

The Hoyt limestone is composed of alternating beds of dolomite and of limestone, and is comparatively thick bedded. The color is usually dark and often black. Several beds of black oolite occur, chiefly in the lower portion of the formation. Many of the limestone beds furnish abundant fossils, chiefly trilobites in very fragmentary condition. Along with these are small gastropods, which are much less abundant. Lingulella acuminata occurs everywhere. Perhaps the most striking fossils of the formation are the big, reeflike masses of the organism of unknown nature, known as Cryptozoon. The genus was originally described by Hall from the exposures by the roadside just north of the Hoyt quarry (plates 3 and 4), where a bared and glaciated surface of the rock is splendidly exposed over a considerable area. Reefs and masses of more than one species of this genus are of common occurrence in both the Hoyt limestone and the overlying Little Falls dolomite, in the latter ranging throughout the Mohawk and Champlain valleys. The reeflike nature of the masses is well shown in many places in the district, notably so perhaps in the railroad cut just east of Greenfield depot. Midway of this cut is shown a Cryptozoon reef of massive limestone (6 feet thick). Toward the west this bed breaks up into thinner bedded material which at the same time becomes very sandy and with layers of nearly pure quartz sand, while to the east it remains pure limestone, though the Cryptozoon gives out. The east is taken to be the seaward and the west the landward side of the old reef.

The Hoyt limestone is well shown in the so-called railroad quarry, 1 mile north of Saratoga (plates 5 and 6). But neither base nor summit shows there and the outcrop is an isolated one lying between two branches of a fault, so that it tells nothing whatever in regard to the stratigraphic relations of the formation. It has a local high dip to the southwest due to proximity to a fault, shows a thickness of some 20 feet of the formation including a splendid Cryptozoon reef, and is an excellent locality for fossils. But for the stratigraphy we must go to the exposures in the railroad cuts and the vicinity of the Hoyt quarry. Here an excellent section of the greater part of the formation is obtained, overlying the Theresa formation, hence making certain its stratigraphic position. The summit, however, is not seen, though if we are correct in

[1] N. Y. State Mus. Bul. 153, p. 30.

Digitized by Google

assigning the exposures at the crossroads at South Greenfield to the base of the Little Falls dolomite, then the section closes in beds not far from the top. The section has already been published and is here repeated, numbered in continuation of the Theresa section already given.

		FEET	INCHES
40	Exposures at Hoyt quarry: hard, blue to black, subcrystalline to crystalline magnesian limestone, largely of dolomite rhombs with calcite cement; 1 foot from the top is a Cryptozoon reef bed, and the section rests on another such bed, which is the same as the one shown by the roadside (plates 3 and 4); the rock is partly thin and partly thick bedded; some of the layers show coarsely crystalline calcite cement, giving large glittering cleavage faces on freshly broken surfaces; trilobites, gastropods and Lingulella are found throughout	25	....
	One-third of a mile north of the Hoyt quarry is another quarry face by the roadside, capped by the same Cryptozoon layer which forms the base of the Hoyt quarry section, but was not included in the 25 feet of that section.		
39	Dark blue, subcrystalline, magnesian limestone full of Cryptozoon; frequent black, oolitic grains	1	5
38	Massive beds of blue, finely crystalline, magnesian limestone, with occasional sand grains; trilobite fragments	5	5
37	Thin bed of calcareous sandstone, weathering to brown, rotten stone	....	5
36	Two beds of dark blue, crystalline, magnesian limestone with some sand grains	2	5
35	Layer of dark gray, calcareous sandstone	1	7
34	Light colored, vitreous sandstone with films of darker, calcareous material	1	3
33	Dark colored sandstone with calcareous cement	....	4
	Four-tenths of a mile northeast of this are two considerable cuts along the railroad in which the following section is shown (plate 7). The hiatus is estimated at	20	....

Digitized by Google

Plate 3

H. P. Cushing, photo, 1910

Cryptozoon proliferum Hall. Glaciated exposure of one of the Cryptozoon reef beds of the Hoyt limestone, by the roadside near the Hoyt quarry. Original locality of Hall's figure of the species.

Digitized by Google

Digitized by Google

Plate 4

H. P. Cushing, photo, 1910

Another view of the Cryptozoon surface, same locality. Both views show foreshortening due to down-pointing of the camera.

Digitized by Google

Digitized by Google

		FEET	INCHES
32	Dark blue, subcrystalline, magnesian limestone....	1	3
31	Blackish, oolitic dolomite.....	1	8
30	Dark blue, crystalline dolomite, calcite cement which shows large cleavage faces; holds Lingulepis acuminata	....	10
29	Black, oolitic dolomite containing pebbles of mud limestone	1	8
28	Rotten, crystalline dolomite, calcite cement rapidly leaching out	....	5
27	Blackish, oolitic dolomite in three beds, the upper a Cryptozoon bed; frequent sand grains and many drusy cavities with quartz and calcite crystals	2	6
26	Easily rotting crystalline dolomite, calcite cement, very shaly above.....	....	9
25	Hard, light colored, vitreous sandstone.....	1	4
24	Crystalline bluish dolomite, calcite cement.....	1	7
23	Two massive beds of blackish, subcrystalline magnesian limestone, with frequent sand grains.....	4	3
22	Concealed between the two railroad cuts; boundary between Hoyt limestone and Theresa formation in the interval.....	20	....
		94	1

Several points brought out by this section need to be noted. Vitreous sandstones run up in it for nearly 60 feet above the base, and there may be some question in regard to the classification of this portion of the section. The sandstones are not so numerous as in corresponding portions of the Theresa section elsewhere; the black oolitic and magnesian limestone beds are quite characteristic of the Hoyt, and not so much so of the normal Theresa. The section brings out clearly the fact that the Hoyt lies above the Theresa passage beds and is followed by the Little Falls and that the same interval elsewhere is occupied by a thickness of passage beds equal to the combined thickness of the Hoyt and Theresa of the Saratoga section. In other words, the Hoyt is a local phase of the upper Theresa, probably a more offshore phase. It is exposed only at Saratoga because only here has erosion cut down to this phase. Elsewhere the near shore phase of the formation is exposed and

Digitized by Google

the extension of the Hoyt lies to the east and south of Saratoga, buried from sight beneath the younger rocks which cover it in those directions. The waters were clearer, less subject to incursions of sand, Cryptozoon reefs flourished as they did not in the normal Theresa, and trilobites and gastropods lived on the surface of the reefs, where we find their fossil remains abundantly today.

To the thickness of the Hoyt limestone as here measured there needs to be added an unknown amount which we estimate as probably not over 25 feet, in order to reach the summit of the formation.

From the Hoyt limestone we collected the following fauna: Cryptozoon proliferum, Lingulella (Lingulepis) acuminata, Triblidium cornutaforme, Matherella saratogensis, (Murchisonia) sp. indet., Matthewia variabilis, Pelagiella hoyti, P. minutissima, Agraulos saratogensis, Lonchocephalus calciferus, Dicellocephalus hartti, D. tribulis.

LITTLE FALLS DOLOMITE

General statement. The name "Calciferous" was originally applied to the considerable thickness of dolomitic rocks which overlies the Potsdam sandstone in the Champlain and Mohawk valleys. Later on Clarke and Schuchert replaced this by the name Beekmantown, and to the rather unfossiliferous phase of the formation in the Mohawk valley gave the local name of Little Falls dolomite. Brainard and Seely were the first carefully to measure and subdivide the formation in the Champlain valley, making five subdivisions which they lettered from A to E.[1] Recent work of Ulrich, Ruedemann and Cushing showed that the Little Falls dolomite of the Mohawk valley was the equivalent of division A and the lower part of division B of the Champlain Beekmantown, and that divisions C, D and E were absent along the Mohawk; furthermore that an unconformity everywhere separated the Little Falls from the overlying Beekmantown, and that the natural affiliations of the former were with the Potsdam and Theresa beneath, rather than with the Beekmantown above, both structurally and faunally.[2] In the Saratoga region the Little Falls is present and the Beekmantown wholly absent. The lowest division of the Beekmantown,

[1] Am. Mus. Nat. Hist. Bul. 3, p. 1.

[2] N. Y. State Mus. Bul. 140, p. 97–140.

Digitized by Google

Plate 5

H. P. Cushing, photo, 1910

Railroad quarry in Hoyt limestone, 1 mile north of Saratoga, looking northeast, showing the railroad cut and the quarry to the west. The beds are the same as those at the Hoyt quarry.

Digitized by Google

Digitized by Google

Plate 6

H. P. Cushing, photo, 1910

North end of the quarry shown in plate 5, looking northwest and showing the strong southwesterly dip.

Digitized by Google

Digitized by Google

the Tribes Hill limestone, may have been deposited here and later removed by erosion. The remainder of the Beekmantown was probably never deposited about Saratoga or along the Mohawk.

Description. The Little Falls dolomite is composed chiefly of rather massive beds of gray dolomite. The larger part of the formation consists of dark gray, fine grained beds. Many of these contain some calcite, chiefly as a cement binding the dolomite crystals together. On weathered surfaces the dolomite is the more resistent of the two, the calcite is dissolved, leaving somewhat projecting dolomite crystals and giving a porous, sandy appearance to the weathered surface. Beds of this type are best exposed along North Broadway as the road climbs the hill south of St Clements.

In addition there is a considerable thickness of more coarsely crystalline, lighter colored dolomite in the formation. About Saratoga such beds form the summit of the formation and are exposed in many places, perhaps best in the Maple Avenue quarry. They are, in general, quite pure dolomite, lacking the calcite cement which occurs so generally in the darker beds (plate 8).

It is impossible to get any very correct idea of the thickness of the Little Falls dolomite, from the exposures of the quadrangle. There is not sufficient variation in the character of the rock to enable one to assign the beds of the scattered exposures to their proper horizon in the formation; and faults so abound that nothing like a continuous section of the entire formation exists in the region. At Saratoga Springs the exposures are in a triangular fault block, and the exposed thickness is 119 feet.[1] This is the upper portion of the formation and gives no clue to the amount beneath which is lacking. Two deep wells have been drilled at Saratoga with the diamond drill, with careful preservation of the drill cores, one at the Congress and the other at the Hathorn spring. We have had the opportunity to study the former, though we have unfortunately not been able to see the latter. Each well went down near the Saratoga fault, and each must rest under the suspicion of having crossed a small branch of the fault in such way as to duplicate part of the well section and increase the apparent thickness. In the Congress well 18 feet, 2 inches of drift was passed through, then 18 feet, 7 inches of Amsterdam limestone, after which the entire core of the well, some 281 feet, consisted of Little Falls dolomite. The upper 40 feet of this was of the characteristic coarsely crystalline, light colored dolomite which forms the upper part of the formation about

[1] N. Y. State Mus. Bul. 140, p. 108–9.

Digitized by Google

Saratoga. Beneath this was 180 feet of darker colored dolomite of varying grain, the upper and lower portions through a thickness of some 50 feet each coarser than the center. The upper part had many nodules of crystalline calcite. Underneath this was a recurrence of coarse, light colored beds. This gave rise to the suspicion that perhaps a fault was crossed here causing a reappearance of the upper beds of the formation. But no suggestion of a fault was given in the appearance of the drill core, and a careful comparison of this portion with the upper portion did not show any exact correspondence. There was also a greater thickness of the coarse beds here than above. Below, dark beds came in again and the well terminated in these. If this section is really unbroken, then the thickness of the formation is certainly 300 feet and may be considerably more.

The Hathorn well was 1006 feet deep. After 62 feet of drift the drill entered the Amsterdam limestone. The bottom 231 feet were reported as Potsdam, but the thickness suggests that the Theresa is also included and perhaps the basal Hoyt. Assuming it to represent Potsdam and Theresa, and deducting this thickness and the drift thickness from the total of the well, leaves yet a thickness of over 700 feet for the combined Amsterdam, Little Falls and Hoyt formations. If the bore does not cross a fault this would mean a thickness of from 500 to 550 feet for the Little Falls which is considerably in excess of any known thickness elsewhere possessed by the formation. It is doubtful if it exceeds 350 feet in the Saratoga region, though it may reach 400, which is as great a thickness as it is known to reach at any point.

There is much chert in the formation. Black chert is the most abundant but gray chert is by no means uncommon. The upper beds of the formation are heavily charged with chert in nearly all localities throughout its extent, and Saratoga is no exception to the general rule. The upper bed at the Maple Avenue quarry is full of chert. The lower beds of the formation are also heavily charged with it. These beds are best seen about a mile south of Porter Corners.

The formation is everywhere exceedingly unfossiliferous. *Lingulella acuminata* is occasionally found in the lower beds, and a few fossils are sometimes to be seen in the upper cherts. The most common fossil, however, is Cryptozoon, reefs of which occur throughout the formation. This is the only fossil which we have seen in the formation about Saratoga. In most of the formation the

Digitized by Google

Plate 7

W. J. Miller, photo.

Photograph of a hand specimen showing the contact between diabase and Grenville limestone from the Asbestos mine three-fourths of a mile southeast of Thurman village. Nearly natural size. The zones numbered on the left side correspond to those described on page 43. Zone 4 is scarcely brought out in the picture and zone 3 is best shown on the right side.

Digitized by Google

Digitized by Google

Plate 7

Potsdam sandstone in 3″ cut on Adirondack R. R

Digitized by Google

Digitized by Google

Plate 8

H. P. Cushing, photo, 1910

Upper beds of Little Falls dolomite in cliff back of High Rock spring, Saratoga. The cliff face is the fault scarp of the upthrow side of the Saratoga fault.

Digitized by Google

Digitized by Google

Cryptozoon is C. proliferum, but in the upper beds another and quite different species comes in. A bed of dove limestone which occurs capping the upper, light colored dolomite to the west of Saratoga, exposes this Cryptozoon most excellently (plates 9 and 10). The same species occurs at the summit of the formation at Ticonderoga and elsewhere. The summit beds are usually full of chert and the Cryptozoon is often heavily silicified.

Unconformity at the summit of the Little Falls. The Little Falls dolomite is directly overlaid, in the Saratoga region, by the Amsterdam limestone of upper Black River age. No representatives of the Beekmantown and Chazy groups appear in the section, and the lower beds of the Black River group are also lacking. The Tribes Hill limestone, which overlies the Little Falls in the Mohawk valley and is of probable lowest Beekmantown age, is absent about Saratoga. It may have been thinly deposited and subsequently eroded. It seems quite safe to say that the Beekmantown and Chazy deposits never reached the district, and that the lower Black River rocks were laid down but thinly if at all.

Aside from the absence of these rocks from the region, the physical evidence of the unconformity is twofold. The base of the Amsterdam rests on quite different beds of the Little Falls, at the various exposures of the contact, indicating erosion of the surface prior to Amsterdam deposit; and the basal bed of the Amsterdam varies from place to place, showing that the surface upon which it was laid down was irregular and that the lower beds of the Amsterdam are only found in the old depressions. Furthermore the Amsterdam begins with a basal conglomerate full of Little Falls pebbles. This basal layer is best seen at Saratoga. In the northern part of the village, just west of the fault line and just north of where the Delaware & Hudson Railroad crosses the fault, thin patches of this conglomerate may be seen resting on the upper surface of the Little Falls, proving that it is the very top of that formation which there forms the upthrow face of the fault.

AMSTERDAM LIMESTONE

In the sections of the eastern Mohawk region there appears, beneath the rocks which are strictly referable to the Trenton group, a thin limestone formation which is wholly distinct from anything found in the vicinity of Trenton Falls and which we regard as an upper member of the Black River group and are calling the Amsterdam limestone. A detailed account of the formation in the type

Digitized by Google

region has not yet been published, but it is hoped that it will soon appear. A preliminary statement concerning it has already been made.[1]

Within the Saratoga quadrangle this limestone is seldom exposed, owing to heavy covering of glacial drift. The best and most complete section of it is at Rock City Falls, where the contact with the underlying Little Falls dolomite is exposed. At Saratoga the base is thinly exposed and a wedge of the formation is infaulted along the Saratoga fault, exposed back of the Star spring and for a short distance northward. There is a good exposure at Rowlands mill, which, however, does not show the base; and there are other exposures through North Milton, the best folded into a little syncline. There is also a small exposure of basal Amsterdam and summit Little Falls, drop-faulted along the West Galway fault, south of East Galway. Nowhere within the quadrangle has the summit been seen exposed, except perhaps at Rowlands mill.

The best section and the one exposing the lowest beds, is that at Rock City Falls (plate 11). The section here had been previously measured by Prosser.[2] There is some 14 feet of Little Falls dolomite in the face of the fall, gray, finely crystalline dolomite for the most part, full of black seams, occasional nodules of crystalline calcite, and with much chert midway. The horizon seems beneath that of the coarser, light colored beds, such as form the summit about Saratoga, and they have likely been removed by erosion. The contact shows slight irregularity, as it does at Saratoga. The lower 3 feet of the overlying beds have a look of the Lowville and were referred to that formation by Prosser. We collected some fossils from them, however, which seemed to belong to the Amsterdam, though we are somewhat in doubt in the matter. If this be Lowville it is the only occurrence of this formation seen within the quadrangle limits. Above follow 38 feet of Amsterdam, somewhat thin-bedded, crystalline fossiliferous limestone of blue color. Not only are the Lowville-looking beds absent elsewhere but the succeeding 15 feet is also absent in the North Milton sections, the higher beds resting directly on the Little Falls there. At Rowlands mill and in the North Milton sections the summit shown is thinner bedded and likely above anything in the Rock City Falls section. About North Milton are a half dozen exposures, chiefly pinched into a little syncline with the upper Little Falls, as shown on the areal map.

[1] Am. Jour. Sci., 31:143.

[2] N. Y. State Mus. Bul. 34, p. 476.

Digitized by Google

Plate 9

H. P. Cushing, photo, 1911

Glaciated surface of Cryptozoon at summit of Little Falls dolomite, 4 miles west of Saratoga. This is a different species from the C. proliferum shown in plates 3 and 4 and is a characteristic form in the upper Little Falls dolomite.

Digitized by Google

Digitized by Google

Plate 10

H. P. Cushing, photo, 1911.

Another portion of the Cryptozoon reef shown in plate 10; in the background appears the exposure shown in the previous view; the picture was taken just after a shower and the dark patch is a portion of the surface that had not yet dried.

Digitized by Google

Digitized by Google

Since the actual summit nowhere shows, we are somewhat in doubt as to the actual thickness of the formation and as to what directly overlies. The many drilled wells to the south of Saratoga aid in supplying the information. Underneath the Canajoharie shale these wells show an average thickness of from 40 to 45 feet of alternating shale and limestone, beneath which comes 35 to 40 feet of limestone and then the Little Falls. The limestone is Amsterdam. Whether any of the alternating shale and limestone is also to be classed as Amsterdam we do not know. We have seen but one exposure of the horizon, in a cut by the roadside a mile east of Rock City Falls, an exposure so poor as really not to merit the name. The fauna was Trenton, not Amsterdam; but the exposure may not have been basal. We incline to the opinion that this alternating shale and limestone is all Trenton, and that the thickness of the Amsterdam is from 40 to 60 feet, varying with the irregularity of the floor on which it was deposited.

The appended list of the more common fossils of the Amsterdam we owe to the courtesy of Dr E. O. Ulrich:

Solenopora compacta
Stictoporella cribrosa
Rhinidictya mutabilis
Phyllodictya varia
Eridotrypa minor
Arthroclema pulchellum?
Pachydictya acuta var.
Columnaria halli
Strophomena trentonensis
Dalmanella rogata
Dinorthis pectinella
Bathyurus spiniger
Leperditia n. sp.

GLENS FALLS (BASAL TRENTON) LIMESTONE

The zone of alternating shale and limestone, some 40 feet thick, which overlies the Amsterdam in the well sections and which is not exposed at the surface, is the only zone in the district to which the term Trenton limestone could at all properly be applied, and there is even question as to its propriety here since the shale exceeds the limestone. Outcrops on the Broadalbin quadrangle and in the eastern Mohawk valley, where the sections are exceedingly like those about Saratoga, leave little doubt that this zone is of lower Trenton age. On the Broadalbin quadrangle Miller has mapped this zone with the Amsterdam, and separate from the overlying Canajoharie shale. The Canajoharie shale, however, is of Trenton age, and it seems to us more fitting to group the basal zone which contains the thin limestone bands with this, as its basal portion, rather than with the Amsterdam, which we regard as of Black

Digitized by Google

River age. Ruedemann has termed this limestone the *Glens Falls limestone,* since its fauna has shown it to lie below beds of the Trenton Falls section.[1]

THE CANAJOHARIE SHALE

BY R. RUEDEMANN

The Canajoharie shale is the surface rock in the southernmost area of the Saratoga quadrangle and thence extends northeast, occupying the area between the Snake Hill formation of the eastern trough and the McGregor fault and its branches. West of Saratoga it rests directly on the basal or Glens Falls limestone and southward the formation strikes toward the Mohawk river near which it passes under the Schenectady beds. Northward from the Schuylerville quadrangle it has not been traced beyond Glens Falls, the constituent divisions of the shale belt north of the Hudson valley having not yet been differentiated.

This formation, which is most typically developed in the Mohawk valley, has been fully described by the writer in Bulletin 162. It consists almost entirely of soft black, carbonaceous, more or less calcareous, argillaceous shales and is therefore quite distinct in its lithologic characters from the Normanskill-Snake Hill group, although where it has become involved in the folding, as in Albany county, it may through cleavage and slickensided slip planes become quite similar to some of the darker shales of the latter formations. It lacks, however, the smooth, lighter colored, gray, greenish and bluish purely argillaceous shales so prevalent in them, and the black Canajoharie shale weathers a characteristic light drab, like the Utica shale, while the dark shales of the Normanskill-Snake Hill weather grayish brown or spotted or whitish when somewhat siliceous. Nor does the Canajoharie contain any trace of the white weathering chert beds and grit of the shales of the eastern trough. A sandstone bed 2 to 3 feet thick was observed in only one case in the Snook kill below Gansevoort, although thinner layers of somewhat sandy shale are sometimes met with. On the other hand there frequently occur harder, bluish gray mud beds indurated by calcite which are mostly 3 to 6 inches but sometimes 3 to 4 feet thick, as in the bank of the Kayaderosseras creek above Ballston Spa. These mud beds break conchoidal or lumpy and are very fine grained. The shale is fissile and splintery

[1] N. Y. State Mus. Bul. 162, p. 22.

Digitized by Google

for the most part. Its uniform, carbonaceous, fine grained character is the most distinguishing feature of the formation.

Much of the shale contains pyrite which, becoming oxydized, fills the cleavage and bedding planes in some places with rusty brown films and produces efflorescences of alum salts on the protected walls of cliffs, as about Ballston Spa, and is probably also responsible for the occurrence of sulphuretted hydrogen in some of the springs. In some cases the graptolites were found very well preserved in pyrite.

These shales are flat on the two quadrangles here described, and are not involved in the intensive folding and overthrusting that has affected the Georgian, Normanskill and Snake Hill beds, although they may dip steeply near the fault planes. Owing to their uniform softness and flat position, they have not only been very deeply eroded but also fail to form ridges of folded harder beds, as the other shale formations of the region do. Outcrops are therefore extremely scarce in the entire belt, occurring only where the creeks have accidentally reached a higher part of the shale surface, that for the most part is deeply buried under drift. Since practically every outcrop of this shale is fossiliferous, most outcrops are marked on the map as fossil localities.

On the Saratoga quadrangle the most important outcrops are about Ballston Spa where the Kayaderosseras flows between cliffs of this shale 100 feet high. A few small outcrops sufficient to demonstrate the areal extent of the formation were observed in the bed of the Glowegee and its branches, in the southwest corner of the Saratoga map, and another in the creek bed at the Geyser and Carlsbad springs 2 miles southwest of Saratoga Springs. Thence northeastward all rock is hopelessly buried under sand until the Snook kill is reached, which in its upper branches exposes shale cliffs at the foot of Mt McGregor and falls and flows over Canajoharie rock for several miles north of Gansevoort. It again reaches bedrock about 4 miles above the mouth of the creek.

The *thickness* of this formation could not be determined in the area here mapped from the facts at hand. We know, however, that not more than 15 miles to the southwest it is not less than 1100 feet and there is no reason why it should originally have greatly diminished toward Saratoga county, this direction lying in line with the probable axis of the trough in which deposition took place. Since, however, the shale in this region was earlier uncovered by erosion than the belt at the foot of the Helderberg escarpment, it

Digitized by Google

probably has suffered a longer erosion and may for that reason be now much reduced in thickness.

The fauna of these shales on the two quadrangles is small but present in all outcrops and characteristic of the formation. It consists of the graptolites:

Corynoides calicularis *Nicholson*
Dicranograptus nicholsoni *Hopkinson*
Diplograptus amplexicaulis *Hall*
D. (Mesograptus) putillus *Hall*
D. (Mesograptus) mohawkensis *Rued.*
Climacograptus spiniferus *Rued.*
Glossograptus quadrimucronatus *mut.* cornutus *Rued.* and other mutations
Lasiograptus eucharis (*Hall*)

Besides these there are met with worms (Eopolychaetus albaniensis and Pontobdellopsis cometa) described from this formation by the writer in Bulletin 42 (1901) and small brachiopods (Leptobolus insignis Hall, Schizocrania filosa Hall) and a few cephalopods (Trocholites ammonius Conrad, Orthoceras arcuolineatum Rued., O. hudsonicum Rued.) and rarely a head of a Triarthrus becki. Of these are common only Corynoides calicularis, Climacograptus spiniferus, Diplograptus amplexicaulis, putillus, mohawkensis and Lasiograptus eucharis. Dicranograptus nicholsoni, so common in the Snake Hill beds, is very rare, while Lasiograptus eucharis is present in every outcrop; the other graptolites here cited are not always associated but rather distributed in subzones of the formation not yet distinguished. Thus in Ballston Spa the beds exposed in the village are full of Climacograptus spiniferus and Diplograptus amplexicaulis, but going up the Kayaderosseras creek one first meets thick-bedded mud shales and above these Glossograptus quadrimucronatus mut. and Lasiograptus eucharis have become the dominant forms. The outcrop at the Carlsbad Spring near Saratoga contains:

Diplograptus (Mesograptus) mohawkensis
Climacograptus spiniferus, and
Lasiograptus eucharis

Digitized by Google

As a rule, one meets only Corynoides calicularis and Lasiograptus eucharis, the two most common fossils, as at the Glowegee and the upper branches of the Snook kill. At the Gansevoort fall, however, also Glossograptus quadrimucronatus mut. cornutus, a characteristic form of an upper horizon of the Canajoharie shale was obtained in typical specimens.

Correlation. We have shown in another paper,[1] that the Canajoharie is of lower Trenton age and essentially contemporaneous with the Snake Hill shale. The two have, therefore, some important horizon markers, especially graptolites, in common. While, however, the Snake Hill shale rests on either upper Normanskill shale or Rysedorph Hill conglomerate and belongs to a vertical series that begins with the Georgian beds at the bottom, the Canajoharie shale can be seen to rest on the basal Trenton limestone at Glens Falls, the latter being underlain in turn by the Amsterdam limestone. It is therefore to be inferred that although the Canajoharie and Snake Hill shales may be approximately synchronous, they were formed in different basins and have come in contact through later diastrophic movements (see diagram and page 100.)

The Canajoharie shale is equivalent to the lower part of the Martinsburg shale in Pennsylvania and New Jersey, with which it has the characteristic fossils in common and is probably continuous with it through southern New York. The Martinsburg shale, however, comprises also beds of Utica and Eden age.

THE SCHENECTADY FORMATION

In the southwestern corner of the Saratoga sheet, from Birchton westward, the grits of the Schenectady formation are exposed in a number of places, showing that this formation just reaches the sheet from the southwest.

The Schenectady formation consists in the lower Mohawk valley of 2000 feet of grits and sandstones with interbedded black and gray argillaceous shales, the two forming a monotonous, uniformly alternating series throughout this great thickness. The sandstone beds are quarried about Schenectady and Aqueduct, and in the latter place, where the Mohawk river in its new postglacial course breaks through a ridge of these harder beds, an excellent section of a portion of the formation is furnished. These gray, impure sandstones and gray to black argillaceous shales have, until recently,

[1] N. Y. State Mus. Bul. 162, p. 29.

Digitized by Google

been currently correlated with the "Hudson River," Lorraine or Frankfort formations, mainly for the reason that they overlie the black (Canajoharie) shales, which were identified with the Utica shale; further because they are lithologically like the Lorraine beds; and, finally, because they seem to be continuous westward with the Frankfort shale, the lower division of the Lorraine group as it was hitherto understood. Recent investigations by the writer[1] have, however, shown that this thick formation contains a fauna not younger than Trenton, that the underlying black shale is not Utica but early Trenton in age, and that these sandstones and shales are only apparently continuous with the Frankfort of the Mohawk, the Frankfort pinching out gradually eastward and the Schenectady beds rapidly thinning out westward. The Schenectady formation is therefore now considered as of middle and upper Trenton age.

The life of this formation has proved to be an extremely peculiar one. It consists of a few graptolites, brachiopods, cephalopods, lamellibranchs, trilobites and ostracods of upper Trenton aspect, with prenuncial Utica forms, but besides there occurs, in certain layers, a profuse mass of fragments of new eurypterids and seaweeds (*Sphenophycus latifolius*). Ten species of eurypterids, belonging to various genera, have so far been recognized, but it is obvious from fragments of sculptured pieces of integument that the fauna was still greater. The seaweeds, the rapid alternations of shales and sandstones and the mud cracks indicate that the great thickness of beds was deposited in shallow water, and the uniformity of the formation shows that this water kept deepening approximately proportional to the accumulation of the sediments. The formation extends mainly from southwest to northeast in a trough that is here termed the lower Mohawk or western trough.

While at present the formation reaches only the southwestern corner of the Saratoga quadrangle, its great thickness on the adjoining Schenectady quadrangle, and the fact that the strike of the formation is in the direction of this sheet, leave no doubt that it once extended much farther north, probably across the sheet, and has since been eroded away.

The edge of the formation forms now a low escarpment, shown by the contour lines in the very southwest corner of the sheet, and this, like the typical Helderberg escarpment, farther south, is clear evidence of the former extension farther northward of the formation.

[1] *Op. cit.*, p. 50.

Digitized by Google

In front of this low escarpment, at several places along the road leading due north to the Glowegee, small outcrops of dark shales were observed, the shale being sandy in some parts and fissile and argillaceous in others, but nowhere of the character of the Canajoharie shale. This shale we have mapped with the Schenectady beds.[1]

The Indian Ladder beds. The Schenectady beds are overlain in the Helderberg escarpment at the Indian Ladder by a similar formation, 300 feet or more in thickness, that has furnished a faunule hitherto known only from the Eden beds about Cincinnati and of an age roughly corresponding to that of the Frankfort beds in central New York. This formation, which is of small east-west extension, was deposited after an emergence in Utica time in the narrow southern extension of the western trough. The submersion, however, proceeded probably from the south, and it is very probable that it extended over the Saratoga sheet, although no rocks of this period are left there.

STRUCTURAL GEOLOGY OF THE WESTERN BASIN

BY H. P. CUSHING

General statement. The Paleozoic rocks of the western basin have been deformed chiefly by faulting, which has equally affected the Precambric rocks. Folds are not prominent and the rocks show but gentle dips, except locally near faults. The district shows little sign of lateral compression and the faults all appear to be normal. In these two respects arises the chief structural difference between the rocks of the western and eastern basins.

Vanuxem, years ago, described the normal faults which cross the Mohawk valley, from Little Falls to Hoffmans Ferry.[2] The next geologist to consider them in any detail was Darton, who studied and mapped all the Mohawk faults, especially extending the work north of the river, and also carrying it northeastward to include the Saratoga region.[3] This was a most excellent piece of work and has formed the basis for all subsequent investigation of these faults.

[1] Professor Miller has, on the adjoining (Broadalbin) quadrangle, mapped the sandstone-shale alternations of the Schenectady formation as Frankfort beds, and the underlying shale of the same formation, as Utica, the Schenectady beds having at that time not yet been studied by the writer and separated from the Frankfort shale.

[2] Geology, 3d Dist., p. 203–11.

[3] N. Y. State Geol. 14th Ann. Rep't, 1894, p. 33–53.

Digitized by Google

Still more recent work on some of the faults which reach the Saratoga quadrangle has been done by Prosser, Cumings and Fisher in their mapping of the Hoffmans Ferry fault across the Amsterdam quadrangle, near the north edge of which it gives rise to two branches; and by Miller in his mapping of these and other faults of the Broadalbin quadrangle.[1] Of these only the Hoffmans Ferry fault and branches pass over on the Saratoga quadrangle, while other and more easterly faults come in.

All the larger of these Mohawk faults have a trend somewhat to the east of north, and a rude parallelism with one another. To the south they all run into the great thickness of upper Ordovicic shales, and as soon as these come to form the surface rocks on both sides of the fault, it is exceedingly difficult to trace the dislocation farther. We do not as yet know whether they die out in the shales or not. To the north the faults run into the Precambric rocks; and so soon as they have these on both sides of the fault, a similar difficulty arises in the effort to trace them farther. But they seem to run entirely across the Adirondack region from south to north and diminish in frequency toward the west. Hence it results that they abound in the southeast border of the region and are practically absent on the northwest. With their parallelism they divide the region into a great series of rock slices or segments which have shifted up and down past one another and broken the continuity of the rock formations.

The fault planes are seldom visible but such evidence as we have indicates that they are nearly vertical breaks and are all of the type known as normal faults. In the great majority of them the east side has dropped in level relatively to the west side, but in a few of them the reverse is true.

In addition to the relative displacements of the adjacent slices along the fault planes, the upper surfaces of the slices have usually received a tilt toward the west, each slice thus constituting the upthrow side of a fault along its east edge, and the downthrow side of the next fault along its west edge, as illustrated in figure 4.

The faults. Two of the great faults of the Mohawk region, the Hoffmans Ferry (much better abbreviated to Hoffmans) and the McGregor fault, the latter here named for the first time, cross the Saratoga quadrangle. The remaining faults mapped are branches of these two great breaks.

[1] N. Y. State Mus. Bul. 34 and map; Bul. 153 and map.

Digitized by Google

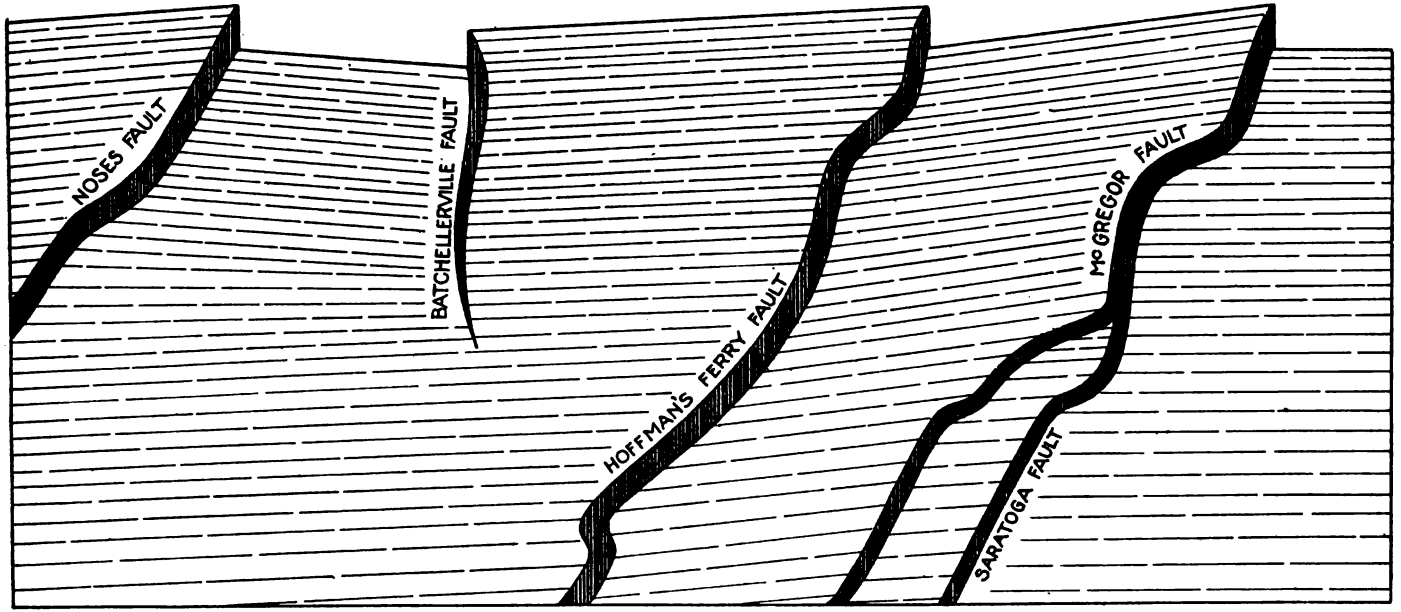


Fig. 4 Diagram of the four principal faults of the Saratoga and Broadalbin quadrangles to illustrate the manner in which they longitudinally slice the country. Minor faults and branch faults are omitted. The Batchellerville fault also is not a member of the principal group but a subsidiary break in the block between the Noses and Hoffmans Ferry faults.
Vertical scale greatly exaggerated.

Digitized by Google

The Hoffmans fault enters the Saratoga quadrangle on its west margin 1 mile northwest of East Galway and, pursuing a general north-northeast course passes on to the Luzerne sheet a mile west of Corinth. At Hoffmans Ferry on the Mohawk (Amsterdam quadrangle) the displacement is estimated by Cumings at 1300 feet and by Prosser at 1600 feet.[1] Near the north edge of the Amsterdam quadrangle the fault sends off two branches to the east, each of which takes part of the throw of the main fault. These two branches, called by Miller the West Galway and East Galway faults, continue across the Broadalbin quadrangle on to Saratoga. Across Broadalbin, Miller estimates the throw of the Hoffman fault as but 250 feet, but states that this rapidly increases in its course across the Saratoga quadrangle.[2]

The scarp of the Hoffmans fault is the most prominent topographic feature of the Saratoga region, though nearly equalled by the McGregor scarp. The summit knobs of the range reach elevations of over 2000 feet, towering as the west wall of the Kayaderosseras valley, the valley floor not greatly exceeding 600 feet altitude. None but Precambric rocks occur west of the fault within the quadrangle; but east of it such heavy drift is banked up against the face of the fault scarp all the way from East Galway to near South Corinth that no rock exposures are seen. About South Corinth Precambric rocks are at the surface east of the fault; about East Galway rocks of the Theresa formation are at the surface. What lies between the two is chiefly conjectural. But the rapid increase in prominence of the fault scarp in passing north from East Galway can, in this instance, be due to nothing except increasing throw. The surface of the western block is tipped to the south more than that of the eastern block. Back from Corinth therefore the throw is equal to the height of the fault scarp plus an unknown amount; hence Miller's estimate of 1000 feet is modest, and the throw is likely 500 feet in excess of that.

To recapitulate: the great throw of the Hoffmans fault at Hoffmans Ferry is split into three parts by the branching of the fault so that, across the Broadalbin quadrangle, the main fault retains only

[1] In vertical faults in nearly horizontal rocks, such as these, the displacement is practically all throw, so far as can be told. At Hoffmans Ferry the surface beds on the western, or upthrow, side of the fault are buried under a thickness of from 1300 to 1600 feet of younger rocks on the opposite side, according to these estimates. Relatively to the beds on the western side the corresponding ones on the east have been vertically dropped by that amount.

[2] N. Y. State Mus. Bul. 153, p. 46.

Digitized by Google

a small fraction of its original throw, the remainder being taken up apparently by the branch faults (West and East Galway faults). Across the Saratoga quadrangle the main fault rapidly regains its original amount of throw. This would naturally suggest a loss of throw in the case of the two branch faults, and such meager evidence as we have in regard to them is corroborative of this suggestion.

West Galway fault. The West and East Galway faults enter the Saratoga quadrangle near its southwestern corner and not greatly over half a mile apart. They are easily traced for 3 or 4 miles when they run into heavily drift-covered territory in which their course, and even their existence, is quite uncertain. Where outcrops reappear, in the northern portion of the quadrangle, two faults are found which are on the trend of these two, and they are assumed to be their prolongations; but the uncertainty of this must be emphasized. If the assumption is correct, interesting consequences follow.

South of East Galway the ravine that runs across the West Galway fault, and which cuts down into the Precambric just west of the fault line (see areal map), gives the data for an approximate estimate of the fault's throw at that point. The Precambric is on one side, the upper portion of the Theresa formation on the other, so that the throw is just about equivalent to the combined thicknesses of the Potsdam and Theresa formations, or from 250 to 300 feet.

Near this point, one and one-half miles south of East Galway, there is a dropped wedge of rock, or horse, along the West Galway fault, which is interesting because the rock concerned is much younger than on either side of the fault. Potsdam sandstone adjoins it on the west or upthrow side of the fault, and the upper beds of the Theresa formation on the other side, the downthrow. The rock of the included wedge is upper Little Falls and basal Amsterdam, hence higher in the section than the Theresa on the downthrow side by the full thickness of the Little Falls dolomite, at least 300 feet. Figure 5 shows a plan of the outcrops and our interpretation of the relations. The wedge of Little Falls and Amsterdam shows abundant outcrops. At the north end of the wedge and *apparently* on the

FIG. 5 Plan of outcrops on the West Galway fault, showing the wedge with Little Falls dolomite at the north and Amsterdam limestone at the south, with two additional outcrops, no. 1 of Theresa beds and no. 2 of Potsdam sandstone.
Scale 1 inch=350 yards.

Digitized by Google

east side of the fault, at a slightly lower level than the nearby Little Falls, is an outcrop of the Theresa passage beds; at the south end, and unquestionably on the west side of the fault, Potsdam sandstone outcrops. Farther west outcrops are plentiful on the west side of the fault but there are none on the east side. The uncertainty in regard to the matter is whether the Theresa is really on the east side of the fault; a slight swinging of the northern apex of the wedge toward the right would put it on the west side. The uncertainty is regrettable; we can only say that everything we saw in the field led to the confident belief in the relations as illustrated, and had not the Theresa exposure been forthcoming we should have been forced to map it at that point owing to the testimony of exposures a mile to the southwest. Nevertheless the drift is very heavy and the mapping of a much faulted district such as this must needs be very uncertain under the circumstances.

Rock horses caught in along faults are common enough. But the rock concerned is usually intermediate in age between the rock of the upthrow and downthrow sides; it has dropped relatively to the upthrow side but has not dropped so far as has the downthrow side. Such a wedge occurs in Saratoga along the Saratoga fault. But in the case under consideration we have a small block about 350 yards in length, which has dropped down along the fault zone some 300 feet more than the downthrow side has dropped. It is a diminutive example of a trough fault. It is difficult to conceive of the mechanical conditions which would permit so small a block to drop so deeply into the jaws of a fault. It may be the apex of a large dropped block, otherwise entirely eroded away.

What seems to be another and similar case is found along the Hoffmans fault a mile west of Porter Corners where a small block of Little Falls dolomite lies in the fault zone closely adjacent to the Precambric exposures to the west of the fault. To the east the drift covers everything, but unless our attempted mapping is totally at fault, the rock on the downthrow side should be the Potsdam sandstone. Certainly Precambric rocks come in on the east side of the fault 2 miles away to the northeast. So we infer this to be a small dropped block of the same type.

As has been said, the mapping of the West Galway fault across the quadrangle is highly conjectural. There should be a fault between the Precambric exposures south of South Corinth and those of the Theresa at North Greenfield; there should be a fault just west of the Potsdam exposures at Corinth, cutting them off.

Digitized by Google

Rock City falls over Calciferous sandstone; student standing on its top with Trenton above.

Digitized by Google

Digitized by Google

These are on the same line with one another and also about on line with the prolongation of the West Galway fault. The throw also is much the same so far as can be judged, but the direct evidence is meager.

East Galway fault. The evidence for the extension of this fault as far as Middlegrove is fairly satisfactory. At first it shows Canajoharie shales on the downthrow side. Back from Rock City Falls the Amsterdam and the Little Falls come in. On the upthrow side the horizon varies but little, the surface of the slice lying very flat. Beyond Middlegrove it runs into the heavy drift, but its trend would be with the axis of the preglacial valley for the next few miles. Farther north its occurrence is problematical, but the presence of a fault is needed to explain the occurrence of the Potsdam and Theresa formations at and south of Corinth, which are wholly out of adjustment with the same formations in the eastern part of Greenfield township. We think a fault must lie here, and it seems more reasonable to connect it with the East Galway fault than to assume a wholly separate break. The chief objection to this view is that the fault south of Corinth downthrows to the west, while at East Galway the downthrow is to the east. This may be explained, however, by the fact that the slice of territory to the west of the fault lies very flat, while to the east of the fault the rocks are more tipped, having a very noticeable southwest dip. Because of this the throw steadily diminishes in passing north as far as a point southeast of Porter Corners, where the Theresa formation is present on both sides of the fault and the throw has become zero. To the northward the throw reverses and the older rocks are present on the east side of the fault instead of on the west. Faults of this type, called "rotatory" faults, are not very common, which is the cause for greater regret, as the heavy drift-covering makes the whole matter so uncertain.

Rock City Falls fault. The small fault at Rock City Falls has been described by both Darton and Prosser. It is well exposed in the creek, the fall itself being practically on the fault line, 15 feet of Little Falls dolomite underlying the Amsterdam on the west or upthrow side, while the base of the Amsterdam is below the creek level on the downthrow side. To the south of the creek also recent quarrying of the Amsterdam has exposed the fault line excellently for a short distance, though with Amsterdam limestone on both sides, a little fault breccia, and with much updrag of the rock on the downthrow side. The throw of the fault is only 25 to 30 feet.

Digitized by Google

Southward it runs into shales and can not be traced. Northward there are indications of it for a mile, beyond which it is hidden by drift.

McGregor fault. Darton spoke of the group of faults about Saratoga as the Saratoga faults. The group seems to us to consist of a main fault with branches and we desire to retain the name Saratoga fault for the branch in the village, often called the "Springs" fault. The grand scarp of the main fault along the front of Mt McGregor has suggested that as a most fitting name for this fault.

In front of Mt McGregor the fault has Precambric rocks on the upthrow side and Canajoharie shale on the downthrow, so that the full thickness of the Potsdam, Theresa, Hoyt, Little Falls and Amsterdam formations is faulted out. This means a minimum thickness of at least 600 feet; in addition there is another thickness of 600 feet of Precambric in the fault scarp, with the summit likely 200 feet below the horizon of the base of the Potsdam. How much thickness of the Canajoharie shale is involved is uncertain, but the throw of the fault is certainly 1400 feet at Mt McGregor, and likely 200 feet more than that. It seems to be increasing toward the north.

Near Kings Station, 4 miles north of Saratoga, a branch fault sets off from the main fault toward the northeast, bringing a block of Little Falls dolomite to the surface between the shales and the Precambric. This may be called the Gurnspring fault. Carbonated waters rise along it in the same way and under very similar structural conditions as they do along the Saratoga fault. This block of dolomite seems cut off at the north by shales, and hence by another fault, but rock outcrops are so few that conditions are very conjectural.

To the northward the McGregor fault runs as one of the prominent breaks of the region, passing to Lake George and forming the prominent fault scarp along the west shore of the lake and of Northwest bay, at the apex of which it passes inland away from the lake.

Between Kings Station and St Clements the McGregor fault runs unbroken, but at the latter place, somewhat over a mile north of Saratoga, it sends off two branches, much diminishing the throw of the main fault. This swerves around to the west and becomes eventually lost under the heavy drift of the Kayaderosseras valley. Its throw is rapidly diminishing and it probably dies out in that district.

Digitized by Google

Woodlawn Park fault. The first of the two branches given off from the main fault at St Clements may be named from this park, as it runs through its northern portion. The only rock outcrop in this portion of the fault block is the Hoyt limestone exposure at the railroad quarry, closely adjacent to Precambric on the north and to Little Falls dolomite on the west and south. Farther south abundant exposures of Little Falls dolomite and overlying Amsterdam limestone occur within the fault block, while across the fault to the southeast is drift-covered territory with Canajoharie shale for the surface rock. Then the fault runs into shales and is lost, as happens to all the faults of the region in like circumstance. The throw of this fault north of Saratoga is just about the thickness of the Little Falls dolomite in amount, hence 300 feet at least.

Saratoga fault. The second branch given off from the main fault at St Clements follows the strike of the main fault into Saratoga and the upthrow side is constituted of the platform of Little Falls dolomite on which the western half of the village is built. At the north edge of the village the strike of the fault swerves somewhat to the west and so continues to West Congress street and Broadway, where it swerves sharply to the west. This part of its course is covered by drift but the change in direction has been disclosed by excavations made for sewers, the data having been furnished by Mr S. J. Mott, the village engineer. By these means the fault has been traced in this direction for something like one-third of a mile, after which its course is largely conjectural.

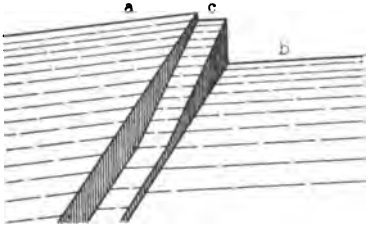


Fig. 6 Diagram of the Saratoga fault and the tipped wedge of Amsterdam limestone in the northern part of Saratoga Springs; a = upthrow side of Little Falls dolomite; b = downthrow side of Canajoharie shale; c = Amsterdam wedge; vertical scale and tilt of wedge surface exaggerated

The fault has long been known because of its close association with the older springs at Saratoga, but when compared with the other breaks of the region its notoriety is found to be out of all proportion to its magnitude. It is but a small break. In its course through the village there is everywhere associated with it a narrow wedge of Amsterdam limestone caught in along the fault zone. This is best seen back of the Star spring and thence northward for a few rods. The low fault scarp, 20 to 25 feet in height, shows the upper beds

Digitized by Google

of the Little Falls dolomite, and is today best shown back of the High Rock spring (plate 8). Small patches of basal Amsterdam lying in contact with the Little Falls somewhat farther north show that this is the very summit of the formation. At the Star spring a wedge of Amsterdam limestone appears lying closely against the fault face and with a tipped upper surface, rising toward the north, falling toward the south. Back of the Red spring it has risen to the full height of the fault scarp; at the High Rock spring it is some 15 feet below the surface of the ground. Figures 6 and 7 clearly show the disposition of this wedge of Amsterdam.

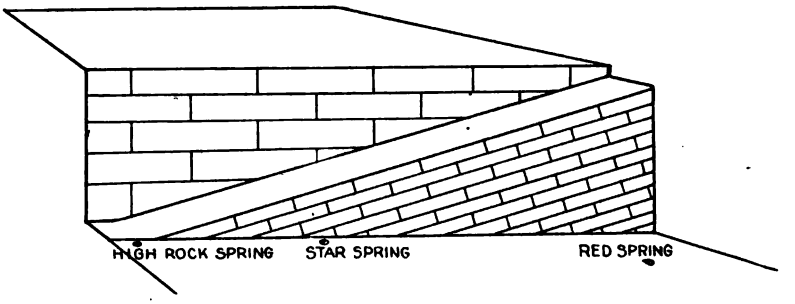


Fig. 7 Illustration of the manner in which the tipped block of Amsterdam limestone lies against the fault face, as seen in looking at the fault from the downthrow side; tilt of block much exaggerated; 1 = Red spring, 2 = Star spring, 3 = High Rock spring

At the Star spring a drilled well gave 38 feet of drift and 62 feet of shale before reaching the summit of the Amsterdam limestone. This well is only a very few yards east of the Amsterdam wedge outcrop and the fault line, showing clearly that the wedge is but a very narrow block caught in along the fault. Ignoring it and estimating the throw of the Saratoga fault from the exposures and the well record at the Star spring, a result of about 160 feet is obtained, 100 feet of drift and shale, 40 feet of Amsterdam limestone and the 20 feet of Little Falls shown in the fault scarp.

The Amsterdam wedge seems to continue along the fault all the way through Saratoga between the two swerves in its course. This is indicated by the fact that it is the surface rock just east of the fault at the Hathorn spring, and also is the surface rock at the Congress spring, as shown by the drill core. It really amounts to a parallel fault lying very close to the main fault. South of the Congress spring its course is lost under heavy drift.

Digitized by Google

Hathorn spring record. The deep bore at the Hathorn spring went down 1006 feet. The driller reported 62 feet of drift at the top and 231 feet of Potsdam sandstone at the bottom, the drill resting in this formation. Amsterdam limestone was found directly under the drift. The Potsdam is so thick that it seems that the full thickness of the Theresa must also be included. If this be the case, the Hoyt, Little Falls, and Amsterdam have a combined thickness of 713 feet, whereas judging by such other evidence as we have of their thickness it should not exceed 450 to 500 feet. This suggests that the drill may have crossed a fault so as to go through a certain thickness of beds twice. This would be quite possible since the drilling started on the Amsterdam wedge and it is only necessary to assume that the branch of the fault east of the wedge hades toward the main fault in order to have just the necessary conditions, as illustrated in figure 8. The drill core is in existence but we have not had opportunity to study it. Such study should show whether any part of the section is duplicated in the record or not. If there is duplication the illustration probably furnishes the reason. If there is none, then the Little Falls dolomite and Hoyt limestone taken together are considerably thicker than we have supposed.

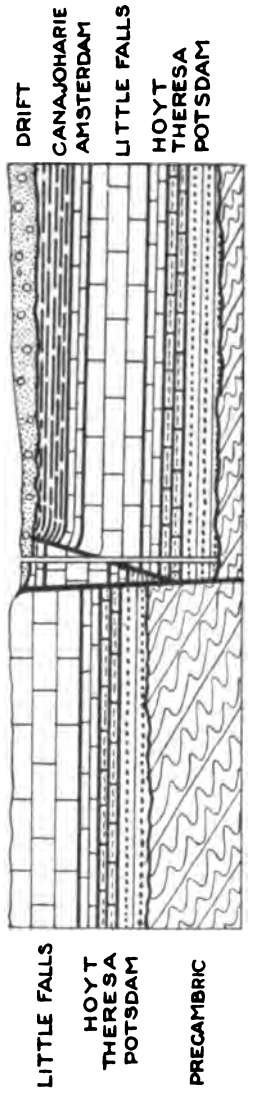


Fig. 8 Diagram to illustrate supposed underground conditions at the Hathorn spring, in explanation of the great thickness of Paleozoic rock shown in the well. Starting in the Amsterdam wedge the bore is thought to pass across the branch fault and repeat part of the section already passed through.

General remarks on the faults. The large faults of the Mohawk and eastern Adirondack regions show a frequent tendency

Digitized by Google

to curve from the north to the northeast and from the northeast back to the north. It has been shown that there are principal joint sets in both these directions in the region and the fault slips are thought to be determined in position by these joints. The average trend of the faults is to the north-northeast. In this direction there are no main joints. The faults maintain this general direction by alternately following the north and the northeast joints, this apparently being a more easy method of accomplishing the deformation with north-northeast trend than the method of creating new fractures in that direction along which the slipping might take place. Both the Hoffmans and the McGregor faults illustrate this curving tendency.

The faults send off frequent branches, which are more likely to appear at a curve. In many cases one branch will be found in a north-south and the other in a northeast-southwest direction. By the branching, the throw of the fault is divided among the branches. It often happens that the throw of the branches steadily diminishes until they fade out while at the same time that of the main fault increases until it attains the amount it had prior to the branching. This process seems frequently repeated.

During the successive stages of the faulting in the region, as the long rock slices slipped past one another, it is but natural that irregularities in the slipping would develop, producing cross strains in the slices and tending to promote cross breaks. That such cross breaks are of frequent occurrence in the general region is quite certain, though exposures are not sufficiently good to permit their certain location within the Saratoga quadrangle. The obvious tendency would be for such cross breaks to occur along planes of weakness, such as the contacts between two formations of very different strength. There seem to be two zones in which such breaks would be most apt to occur, one at the contact between the Precambric crystallines and the Potsdam sandstone, and the other at the contact between the limestones and the overlying shales.

There is some suggestion of frequent cross breaks in the faulted slices at the Precambric-Potsdam contacts, but in no case known to us has the evidence been worked out in detail. A prominent topographic feature of the southeast border of the Adirondacks is the way in which the Precambric portions of the fault slices sharply break down on the south to the level of the Paleozoic plain. In every one of the faulted slices the Precambric rocks are followed by Paleozoic rocks on the south. The Precambric territory

Digitized by Google

is commonly elevated territory, the Paleozoic contrastingly at low altitude. The abrupt way in which such Precambric ridges as those of French and Putnam mountains, and of Sugar Loaf, on the Glens Falls quadrangle, break off at the south, with an abrupt drop in level of from 500 to 800 feet, would seem of necessity to imply cross faulting in the fault slices concerned.

On the Saratoga quadrangle the evidence for cross breaks at the contact between the Amsterdam limestone and the overlying Canajoharie shale seems quite conclusive. The Amsterdam dips to the south are always higher than those of the Little Falls dolomite, showing downfolding or downdragging in that direction, and in the shales the dips are even higher for a time, so that even close to the Amsterdam border the thickness of shale over the limestone is considerable. Exposures do not suffice to determine whether we are dealing with monoclinal folding or with faulting; but since the former could be considered merely an initial phase of the latter, either one would indicate the horizon as a likely one for cross breaks.

Joints. Our readings on joint directions on the Saratoga quadrangle are not sufficiently numerous to make it worth while to plot them. The Precambric rocks cover but a small portion of the quadrangle. They are as usual much jointed nearly everywhere and appear to be referable to four sets, a north-south, an east-west, a northeast and a northwest set. But they do not hold their direction true, curving through considerable arcs. In the Grenville strike joints are prominent, in this case the east-west set. Of the vertical joints the northeast set is the most prominent, the north and the northwest less so and more irregular. The Paleozoic rocks are not very sharply jointed in the main, and the joint directions are very irregular.

Digitized by Google

PALEOZOIC ROCKS OF THE EASTERN TROUGH

BY R. RUEDEMANN

All the sedimentary formations of the eastern trough in the Saratoga and Schuylerville quadrangles belong to the Cambric and Ordovicic (Lower Siluric) systems. The following stratigraphic units have been distinguished:

Table of formations exposed

Ordovicic	Trenton	9 Snake Hill shale
		8 Upper Normanskill shale with Rysedorph Hill conglomerate
	Chazy	7 Normanskill shale *s. str.*
	Beekmantown	6 Bald Mountain limestone
		5 Deep Kill shale (possibly present)
		4 Schaghticoke shale
Cambric	Georgian or Taconic	3 Schodack shales and limestones
		2 Eddy Hill grit
		1 Bomoseen grit

The Cambric system is represented only by its lowest group, the Georgian. The Georgian rocks are found only along the eastern edge of the Schuylerville sheet, whence they extend eastward over the Greenwich and Rensselaer plateaus. The discovery and demonstration of the presence of Lower Cambric rocks, now known as Georgian, may be said to have taken place right at this eastern edge, for it was from the neighborhood of Bald mountain that Dr Ebenezer Emmons obtained the fossils Elliptocephalus asaphoides and Atops trilineatus which demonstrated, in that well-known controversy on the Cambric system in America (Emmons's Taconic), the presence of rocks as old as the Primordial stage of Barrande in the slate belt of eastern New York. Through the investigations of Ford, and especially those of Walcott and Dale, the faunas and rock types of the Georgian have become well known. Walcott[1] first clearly separated the Georgian and Ordovician terranes, and Dale[2]

[1] The Taconic System of Emmons. Amer. Jour. Science, 1888, 35:229, 307.

[2] Dale, T. Nelson. New York-Vermont Slate Belt. U. S. Geol. Surv. 10th Ann. Rep't, 1893, p. 153.

Digitized by Google

established the succession of the subdivisions of the Georgian with such accuracy as the great difficulties arising from the extremely disturbed condition of the beds will permit. He distinguishes, in ascending order (see chart facing page 178, *op. cit.*):

A *Olive grit.* Olive green grit (graywacke), more or less massive, spangled with minute scales of hematite or graphite, sometimes with small quartzite beds, frequently calcareous, generally weathering a pale brick red. Associated with it in places a bed of quartzite 12 to 55 feet thick, 50 to 200 feet.

B *Cambric roofing slates.* Roofing slate, grayish green, purple or mixed green and purple, alternating with beds of calcareous quartzite up to 5 feet and limestone breccia up to 40 feet thick. Fauna: Olenellus; Microdiscus lobatus, M. speciosus; M. connexus; Solenopleura, possibly nana; Obolella; Iphidea pannula; Hyolithes communis; Hyolithellus micans; trails of annelids. 200 to 240 feet.

C *Black patch grit.* Dark gray grit or sandstone with black shaly patches, sometimes with calcareous nodules. Olenellus in both grit and calcareous nodules. 10 to 40 feet.

D *Cambric black shale.* Black shale or slate, generally weathering blue black, sometimes pyritiferous, with thin beds of limestone and less frequently limestone breccia. Fauna: Linnarsonia sagittalis var. taconica; Orthis, probably salemensis; Lingula?; Lingulella coelata?; Lingulella granvillensis; Hyolithes communis; Leperditia dermatoidea; Conocoryphe—sp.?; Solenopleura, probably tumida; a phyllocarid crustacean, closely related to Ceratiocaris; spicules of Protospongia; also Microdiscus speciosus; M. lobatus and Iphidea pannula. 50 to 250 feet.

E *Ferruginous quartzite and sandstone.* Quartzite, usually with spots of limonite; in places, however, a bluish calcareous sandstone (grains of quartz with a calcareous and ferruginous cement). 25 to 100 feet.

Professor Dale found 335 to 1400 feet of Lower Cambric rocks exposed but since the thickness of the basal member, the olive grit, is not known, the thickness may easily exceed the maximum. The upper divisions, C, D and E, are described as intermittent and B as often wanting in the western part.

In a later paper Dale[1] has arranged the Georgian beds of the region adjoining south of the one here discussed, somewhat differently. He there constructs the following table of formations:

[1] Dale, T. Nelson. Geology of the Hudson Valley between the Hoosic and the Kinderhook. U. S. Geol. Surv. Bul. 242. 1904, p. 29.

Digitized by Google

Table showing the Lower Cambric series as exposed in Rensselaer county and part of Columbia county, N. Y.

SERIAL LETTER	DESCRIPTION OF STRATA	FAUNA	ESTIMATED THICKNESS IN FEET
J	Greenish shale.....	.....	50
I	Thin-bedded limestone, or dolomitic limestone, in varying alternations with black or greenish shale and calcareous quartz sandstone. Some of the limestone beds brecciated within the sandstone or shale and forming brecciation pebbles, in places, however, beach pebbles	Olenellus fauna.....	[a] 20–200
H	Greenish, reddish, purplish shale, in places with small beds of more or less calcareous quartzite.	Oldhamia, annelid trails	25?–100+
	At Troy, in upper part a 2½ foot bed of calcareous sandstone	Hyolithes and Hyolithellus	
G	Granular quartzite, in places a calcareous sandstone	.....	10–40
F	Olive grit, metamorphic, usually weathering reddish; absent at south	Traces of?.....	18–50
E	Greenish, or reddish and greenish, shale with small quartzite or grit beds	Casts of impressions, Oldhamia [b]	65–535
D	Massive greenish quartzite, in places very coarse	.....	10–50
C	Reddish and greenish shale with small beds of quartzite or grit (rarely up to 5 feet thick)	Casts of impressions, Oldhamia	30–80
B	Massive greenish quartzite, in places very coarse	.....	8–40
A	Reddish and greenish shale with small beds of quartzite or grit, from 1 to 12 and, rarely, 24 inches thick	Casts of impressions, Oldhamia	50–80

[a] Usually 50. [b] Oldhamia occurs in A, C, or E, and quite possibly in all three.

Minimum, 286. Maximum, 1225+

Digitized by Google

A comparison of the two series of divisions, that for the slate belt of Washington county and Vermont and that for Rensselaer county, furnished by Dale, shows that the olive grit in the first is overlain by a great mass of colored slate, the "Cambric roofing slates," and in the latter rests on a still greater mass of colored shales; further that the Cambric roofing slates and the Black patch grit are absent in the latter series, where a granular quartzite 10 to 40 feet thick and a second mass of colored shales 25? to 100+ feet thick intervene between the olive grit and the black shale and thin-bedded limestone. In Washington county this is followed by another quartz mass, the ferruginous quartzite, and in Rensselaer county by greenish shale.

In accordance with the present practice to name the units after their type localities instead of their lithologic and faunistic characteristics and to avoid confusion between the different horizons of colored shales and quartzites, we propose here the following names for these units:

1 *Bomoseen grit* (olive grit). Olive green grit, nearly a pale brick-red. Associated with it in places a bed of quartzite 12 to 55 feet thick. 50 to 200 feet. The type locality of this unit is, according to Dale, on the west side of Lake Bomoseen, Vt., "one-quarter of a mile west of the road running north from Hydeville, on the north side of road to Fairhaven." It is finely exposed about Greenwich, N. Y., especially in ridges northwest of that town, and south on Louse hill, but disappears in Rensselaer county where it still outcrops east and southeast of Troy.

2 *Mettawee slate* (Cambric roofing slate Dale). See definition, page 67. These slates extend typically from Pawlet, Vt., and Granville, N. Y., to Fairhaven, Vt. The town of Granville, which is the center of the industry, would furnish a good name if it were not preoccupied. We have therefore taken the name of the Mettawee river which drains the region.

3 *Eddy Hill grit* (Black patch grit). This formation, which is defined on page 67, is termed from Eddy Hill, near Fairhaven, Vt., where it is seen to rest on the Mettawee slate, and carries fragments of the Olenellus fauna. Its extension southward is not safely established on account of its great similarity to the "Hudson" grit.

4 *Schodack shales and limestones* (Cambric black shale). Defined on page 67. This formation of black shales and limestones always occurs near the top of the Georgian; it is well

Digitized by Google

exposed in many localities, as on Bald mountain near Greenwich, about Granville, etc. The name is taken from the fine exposures two miles south of Schodack Landing, N. Y., on the bank of the Hudson river and the belt of these rocks in the town of Schodack, N. Y.

5 *Nassau beds* (divisions A–E of Dale's series in Rensselaer county). In Rensselaer county the Olive grit or Bomoseen grit is underlain by a series of alternating reddish and greenish shales and quartzites containing Oldhamia, about 150 to 800 feet thick. This is especially well exposed in the town of Nassau, N. Y.

6 *Diamond Rock quartzite* (division G of Dale's Rensselaer series). This division 10 to 40 feet thick and composed of granular quartzite and associated calcareous sandstone, is well exposed in Oakwood cemetery and the "Diamond Rock" in Lansingburgh (North Troy), from which it takes its name.

7 *Troy shales* (division H of Dale's Rensselaer series). This formation, which follows upon the Diamond Rock quartzite, consists of 25 to 100 feet of colored shales with small beds of calcareous quartzite. The shale has furnished Oldhamia, a calcareous sandstone bed in the upper part Hyolithes and Hyolithellus. These beds are well exposed at Troy, at the dam in the Poesten kill and other localities.

8 *Zion Hill quartzite* (Ferruginous quartzite Dale). This name, taken from Zion hill, Hubbardtown, Vt., where according to Dale the ferruginous quartzite is exposed in a thickness of 70 feet, is proposed here for the sake of completeness.

On the Schuylerville sheet we find well represented only division A and the limestone and shales of D. We have separated the areas occupied by these two divisions on the map, the boundaries being only approximate on account of the interfolding of the beds.

The olive grit occupies the southern half of the area. It is easily recognized by the pale brick-red color of the weathered crust that forms on it; typically it is seen on the many ledges north of Greenwich, but it also appears on all sides of Louse hill and extends to the southern boundary of the Georgian areas. From Greenwich the grit skirts the eastern side of Bald mountain. It is described by Dale as follows:

A greenish, usually olive-colored, very rarely purplish, more or less massive grit, generally somewhat calcareous, and almost always spangled with very minute scales of hematite or graphite. Under the microscope it is seen to consist mainly of more or less angular grains of quartz, with a considerable

Digitized by Google

number of plagioclase grains, rarely one of microcline, in a cement of sericite with some calcite and small areas of secondary quartz. There are large scales of muscovite and of a chloritic mineral, scarcely dichroic, and under polarized light a bluish green or prussian blue, with little or no change in rotation. More conspicuous and typical of the rock are scales from 0.043 to 0.130 by 0.020 millimeter, frequently bent, pale green, markedly dichroic, and under polarized light olive or slightly bluish green. These scales contain bands of a colorless mineral parallel to their cleavage, which measure 0.0043 in width and polarize in brilliant orange, emerald or blue. Extinction in both about (if not quite) parallel to cleavage and bands. Finally, there are grains or crystals of a muddy yellow under incident light, probably limonite and that after hematite. The scales of hematite, sometimes graphite, can be made out with a magnifying glass.

This characteristic rock can usually be identified at a distance by the peculiar pale brick-red color of its weathered surface, and, on closer inspection, by the minute spangles and the olive color of the fresh surface.

The olive grit has not furnished any fossils, but it was found full of carbonaceous blotches, suggesting seaweeds, and large worm trails. It is apparently a shallow water deposit.

The belts of heavier grit beds alternate with belts of more slaty, often brownish weathering beds, apparently resulting from the grit through a stronger development of the cleavage. These belts were found to be worn down more, forming the depressions between the ridges of harder grit.

The hills composed of this rock are frequently discerned from a distance through the reddish color of the soil they furnish. The Georgian limestones were also found to weather into soils of reddish tints so that as a whole the Georgian areas of this region can, to a large degree, be distinguished from the Ordovicic shale areas by the soils, wherever the drift is thin or its lower portion exposed, for, as a rule, this also contains so much material derived from the underlying rocks that it partakes of the reddish color. The olive grit forms a belt beginning at the projecting southeast corner of the Georgian area south of Louse hill, continuing over Louse hill and exposed on its north slope, on the banks of the Batten kill, continuing north of Greenwich to the central and eastern peaks of the Bald mountain ridge.

South and east of Louse hill the olive grit or the Bomoseen is flanked by massive ledges of gray quartzite speckled with brown spots of limonite. We consider this bed as corresponding to the massive beds of quartzite found farther east by Dale in association with the Bomoseen grit. On the centre peak of Bald mountain, the Bomoseen grit is flanked on both sides by quartzite beds which are

Digitized by Google

followed by the shales and limestones of the Schodack beds, the whole probably forming an overturned abraded fold. This section would then indicate that the normal sequence is Bomoseen grit, Bomoseen quartzite, Schodack shales and limestone.

None of the typical roofing slates of the eastern part of the slate belt were observed in the Cambric area, but beds of calcareous quartzite, and especially brecciated limestones observed in connection with the Schodack beds, may represent this division.

The Schodack beds are especially well seen in the northern Georgian area of the sheet, where the black and gray shales and the interbedded limestones are everywhere exposed along the road skirting the base of the Georgian plateau in the town of Argyle. This area includes the well-known Bald mountain locality, where the black shales are seen with a thin quartzite bed directly above the quarry on the west side, while on the south side the olive grit has been drawn along the fault line into the shales. On the western slope of Bald mountain the thick-bedded, bluish limestones and interbedded dark gray to black partly arenaceous shale of the formation are well exposed.

Walcott, in his monumental monograph of the Cambric Brachiopoda (1912, page 197), records the following species from this neighborhood:

1 Limestones 1.5 miles (2.4 Km.) north of Bald mountain:

Obolus prindlei (*Walcott*)
Lingulella granvillensis *Walcott*
Obolella crassa (*Hall*)
Botsfordia caelata (*Hall*)
Acrotreta sagittalis taconica (*Walcott*)
Stenotheca rugosa (*Hall*)
Platyceras primaevum *Billings*
Hyolithellus micans *Billings*
H. micans rugosa *Walcott*
H. communis *Billings*
Elliptocephala asaphoides *Emmons*
Solenopleura tumida *Walcott*

2 Shaly limestone on the west slope of the summit of Bald mountain:

Botsfordia caelata (*Hall*)
Acrotreta emmonsi *Walcott*
Olenellus *sp.*

Digitized by Google

Professor Cushing and the writer collected a number of the species here recorded from the first locality and also on Bald mountain.

North of Bald mountain the thin-bedded, bluish (50+ feet thick) limestone is seen in sections to grade into more massive light gray limestone beds which, exposed in cliffs at the fault line, are liable to be confounded with the Bald Mountain limestone and may have led to the extension of the "Trenton" limestone belt farther northward than shown on our map. Georgian brachiopods were found in this massive limestone bed in at least two localities. These limestones were seen in several places to rest on black Cambric shales. It is therefore probable that the Schodack beds contain here some thicker limestone beds than observed in the more eastern region.

The area southeast of Louse hill consists of black shale, a thin-bedded limestone with shale seams and quartzitic bands, with a great number of quartz veins.

Dark gray shales with brecciated limestone pebbles, the beds reaching 200 feet or more (assuming no repetition) in section given on page 81, are exposed at the west edge of the Bald mountain quarry and in the sections north of it. They are interfolded with the Bald Mountain limestone and Rysedorph Hill conglomerate, but have the appearance of the Schodack beds, and are probably Georgian beds forced into the Ordovicic belt near the overthrust plane.

SCHAGHTICOKE SHALE

The Schaghticoke shale with its characteristic faunule, consisting of Dictyonema flabelliforme and Staurograptus dichotomus Emmons var. apertus Ruedemann was discovered by us in a cut of the Hudson Valley Railroad, near the mill of the Standard Wall Paper Company about a mile north of Schuylerville, and thence traced across the lower part of the rapids of the Hudson below Thomson. The entire belt is probably not more than 1000 feet wide and bounded on both sides by outcrops of Normanskill shale; its length is unknown since it runs in both directions under the drift. The rock in the exposure is much contorted and consists for the most part of light greenish gray, glazed argillaceous shale that weathers to a light drab or whitish color with intercalations of coarser light bluish gray more or less sandy mud shale and small streaks of black shale containing the graptolites. It also contains a 3½ feet bed of coarse grit with black calcareous and argillaceous pebbles and large, floating, rounded sand

Digitized by Google

grains. One part of the formation is characterized by a number of calcareous sandstone beds ⅛ to 1 foot thick, which weather into a characteristic chestnut-brown sandy crust. Through the contortions of the beds these rocks are mostly broken into strings of brown boulderlike blocks.

In the river bed where the beds are seen on edge, they appear as greenish gray shales with frequent black shale bands and brown calcareous sandstone beds and some thicker beds of argillaceous mudrock.

These Schaghticoke shales of Schuylerville very much resemble in the alternation of the greenish gray and black argillaceous shales, giving the outcrops on edge a very characteristic banded appearance, the typical Schaghticoke shale as described by the author from the bed of the Hoosic river at Schaghticoke, lacking, however, the intercalated thin limestone bands observed there. They are distinguished from the surrounding Normanskill shale by the absence of white-weathering chert layers and the presence of the chocolate-brown weathering calcareous sandstone; but of course none of these criteria is sufficient to recognize them without the fossil evidence. It is for this reason that they may be outcropping in other localities without having been recognized.

When the author described the Dictyonema flabelliforme or Schaghticoke shale,[1] he followed the consensus of the preceding European authors who considered the shale with Dictyonema flabelliforme as marking the top of the Cambric. Since that time stratigraphers have, especially in Sweden, advanced arguments for placing the Dictyonema bed at the base of the Ordovicic, a proceeding which would also seem to agree well with the condition in the slate belt, since the Dictyonema shale is on one hand separated by a great hiatus from the underlying Georgic, but on the other by its lithologic character and probably also stratigraphically is closely connected with the following Deep Kill shales. Lately Ulrich[2] has also argued for the close stratigraphic connection of the Dictyonema flabelliforme zone with the Tetragraptus zone (the lowest of the Deep Kill zones), and placed the Dictyonema flabelliforme zone in his Canadian system (which comprises the Tribes Hill limestone and Beekmantown B-E).

[1] Ruedemann, R. Cambric Dictyonema Fauna in the Slate Belt of Eastern New York. Pal. Rep't (for 1902) 1903, p. 934.

[2] Ulrich, E. O. Revision of the Paleozoic Systems, pts 1-3. Geol. Soc. Amer. Bul., v. 22, no. 3, p. 678.

Digitized by Google

DEEP KILL SHALE

The Deep Kill shale has not been recognized anywhere on the two quadrangles, but since it lies in the stratigraphical series between the Schaghticoke and Normanskill shales, it is quite possible that small parts of this formation, like that here observed of the Schaghticoke shale, may have been forced up through the extremely disturbed belt of Normanskill shales. Also in this case, the finding of the characteristic graptolites would furnish the only conclusive evidence of its presence, although the lithologic characters of the Deep Kill shale are such that where well exposed they are readily recognized.

BALD MOUNTAIN LIMESTONE [1]

At the western foot of Louse hill near the southwestern corner of the Georgian area, a belt of dolomite and limestone appears on the surface. It can thence be traced northward for about a mile, when it disappears under drift but its presence below the latter is still indicated through the frequent limestone boulders in the drift seen in the stone fences. It then is again well exposed in the ridge skirting the west bank of the Batten kill at its bend south of Middle Falls, in the village of Middle Falls where it causes the fall in the river, and north of Middle Falls in many hillocks protruding through the drift on both sides of the road from Middle Falls to Bald mountain. An excellent locality rich in fossils was found by the writer in an abandoned quarry on the north bank of the Batten kill a quarter of a mile above the village. In front of Bald mountain the beds are now best exposed by the large quarry operations which were carried on there formerly to supply the material for two limekilns still standing west of the road skirting the mountain on the west. From Bald mountain the beds are traceable but half a mile as indicated on the map, but may reappear farther north beyond the limits of the sheet. Southward of Louse hill, this belt fails completely on the west edge of the Georgian in Washington and Rensselaer counties.

This limestone belt is in the neighborhood of Bald mountain, that is at the Bald mountain quarries and northward accompanied by a conglomerate which we have identified with the Rysedorph

[1] Grabau in his paper on the Physical and Faunal Evolution of North America during Ordovicic, etc. Time (Jour. of Geol. 1909) cites a "Bald Mt" formation in the correlation table I, p. 251, but on reference to the text (p. 235) it is seen that the "Bald Eagle (Mountain)" conglomerate is meant.

Digitized by Google

Hill conglomerate, described by the writer from the neighborhood of Albany (see page 80).

This belt was probably first noted by Emmons who indicated it on his map accompanying his Agricultural Report[1] and gave a section through Bald mountain in his paper on the Taconic series in the same report. He identified it with the "Calciferous sandstone" (Beekmantown), distinguishing a blue portion of purer limestone and a lighter one. He included, however, the thin-bedded limestone on top of the mountain in the "Calciferous sandrock." This latter has been shown by Walcott (*op. cit.*, page 317) to be of Cambric (Georgian) age, a fault separating the Georgian rocks from the limestone belt (see chapter on structure of Bald mountain, page 108). Walcott, who first correctly separated on a map the Ordovicic and Lower Cambric areas of the slate belt (*op. cit.*, plate 3), also indicated the extension of the limestone belt and gave a section of Bald mountain in which he distinguished "Calciferous sandrock" (the lower darker rock) separated by dark shales from "Chazy limestone." From a locality (*op. cit.*, page 317) about 2 miles north of Bald mountain, Trenton fossils (Dalmanella testudinaria, Rafinesquina alternata, Maclurea and other gastropods, Calymmene senaria and fragments of Asaphus platycephalus) are cited. It is thus seen that Walcott held the view that the limestone belt contains Calciferous, Chazy and Trenton rocks, a view also expressed on plate 3. Dale has on his map of the slate belt (1899, plate 13) distinguished the limestones simply as lower Siluric (Ordovicic) limestone from the Lower Siluric shale, etc., stating (page 190): "The Trenton limestone occurs sporadically within the Ordovician areas of the slate belt; also on its western edge in Argyle and in Hartford. In some places it was probably deposited contemporaneously with the Hudson grit and shales, or it may underlie a portion of them. In others it may represent the entire Lower Silurian series and should then be regarded as Trenton, Chazy and Calciferous."

We see from this quotation that the determinations of the age of the Ordovicic limestone in the slate belt are rather insecure, a fact that can be readily explained by the scarcity and poor preservation of the fossils usually obtained there.

On the Geologic Map of New York, published by F. J. H. Merrill (1901), the limestone belt on the west edge of the Georgian is entered simply as Trenton.

[1] Emmons, Ebenezer. Agriculture of New York, v. 1, 1846.

Digitized by Google

As far as the part of the limestone belt on the Schuylerville sheet is concerned, our collections have shown that one must there sharply distinguish between the dolomite and limestone on one hand, and the conglomerate on the other, for the former have only furnished fossils of Beekmantown age, and the latter such indicating Black river to Trenton age.

The principal fossiliferous outcrops of the limestones are found in the neighborhood of Middle Falls. The most important one is an old quarry, one-quarter of a mile above the village at the bend of the river, where about 25 feet of highly fossiliferous limestone are exposed. This locality has furnished:

Cryptozoon *sp.*
Girvanella *sp.*
Undescribed sponges
Eccyliopterus planidorsalis *Ulrich* MS
E. planibasalis *Ulrich* MS
Oxydiscus *sp. nov.*
Hormotoma? (Murchisonia) cassina (*Whitfield*), section
Segments of trilobites

A small knoll at the northern outskirt of Middle Falls was found to contain specimens of

Polytoechia apicalis (*Whitfield*)
cf. Protorthis minima *Whitfield*

Along the road from Middle Falls to Bald mountain, dolomite and limestone outcrops are observed on both sides; one of these, west of the road and halfway between Bald mountain and Middle Falls, contained in the limestone, ostracods (undescribed species of Primitia and Leperditia) and fragments of trilobites.

The limestone of the Bald mountain quarry contains cephalopods and gastropods, namely:

Cryptozoon *sp.*
Eccyliopterus planidorsalis *Ulrich* MS
E. planibasalis *Ulrich* MS
Liospira? *sp.* (section)
Cameroceras brainerdi (*Whitfield*)
Cyrtoceras confertissimum *Whitfield*

Cephalopod and gastropod sections were also observed in a small quarry on the roadside at the west foot of Louse hill.

Digitized by Google

These faunules demonstrate the Beekmantown age of the limestone and indicate that it is to be correlated roughly to the Fort Cassin beds, which correspond to unknown parts of Brainerd & Seely's divisions D and E. Since, however, this belt of Beekmantown rocks fully corresponds to the Fort Cassin beds, neither in its lithology nor in its faunal aspect or its stratigraphy, we consider it unsafe to correlate it with the Fort Cassin and shall designate the beds as *Bald Mountain* limestone.

The fauna of the Bald Mountain limestone is distinct from the Fort Cassin fauna, on the one hand in the entire absence of the coiled nautiloid cephalopods so characteristic of that fauna, and, on the other hand, by the prevalence of striking Eccyliopteri, which, according to Ulrich, are identical with forms occurring in the Canadian of Missouri.

The Bald Mountain limestone can neither be correlated nor be continuous with the limestones and dolomites outcropping at the foot of the Adirondacks only a short distance to the west on the Saratoga quadrangle, since these beds, though formerly referred to the Calciferous or Beekmantown, are now known to represent only the lowest division A, and perhaps part of B, which are separated by a great unconformity from the Beekmantown and are claimed even to belong to another system (Ozarkic of Ulrich). It is possible that the Bald Mountain limestone finds its continuation 80 miles farther south in the Wappinger limestone in southeastern New York, but the latter belt includes limestones of Hoyt, Beekmantown, and Mohawkian ages, and the name is therefore not applicable to the possible northern continuation of its Beekmantown portion.

The lower part of this formation consists of dark gray (but sandy gray when weathered), massive, often sandy and also brecciated, practically barren dolomite[1] of which we have seen 40 feet or more, some in beds as much as 6 feet thick. It is well seen in several places, namely, an old quarry on the west bank of the Batten kill half a mile south of Middle Falls, in an abandoned quarry on a hill at the west foot of Louse hill 2¼ miles south of Middle Falls and in a quarry by the road south of Bald mountain. This, like all the limestone and dolomite on Bald mountain, is referred to the Calciferous by Emmons and it is the Calciferous sandrock of Walcott's Bald Mountain section. It is in the neighborhood of Bald

[1] A few sections suggestive of cephalopods and Ophileta were observed in calcareous layers.

Digitized by Google

mountain now best exposed near the two road crossings, the one just west and the other just south of Bald mountain, near the latter crossing in a quarry. The dolomite in the former outcrop is, on account of the complicated overturned and recumbent fold structure of the limestone belt, apparently separated from the limestone by shale beds (see page 109) and so represented by Walcott. The aspect of the dolomite which also contains considerable chert reminds one of the Little Falls dolomite. It is, however, not to be separated as a unit from the limestone, for the two were found to be grading into each other on the road from Middle Falls to Bald mountain and also along the road south of Middle Falls. One instructive locality, a small quarry alongside the road, at the west foot of Louse hill, furnished the following section in descending order:

Thin-bedded limestone	4 feet
Massive limestone bed	3½ feet
Brecciated limestone with gastropods	3 feet
Dolomite bed with irregular band of limestone in middle, full of narrow chambered cephalopods	2 feet, 4 inches
Dolomite bed	1 foot, 2 inches
Brecciated limestone	3 feet

Of the limestone we have seen in one place (west of Louse hill) 70 feet in continuous section, with the top and bottom not exposed. It may therefore reach 100 feet in thickness. It is for the most part fine grained, sometimes approaching the dove-colored limestones, light bluish gray in color with many white crystalline spots. In the lower part it contains somewhat arenaceous bands. It resembles some of the limestone of D of the Champlain valley and also some of the Middle Chazy rocks. Emmons referred it to the Calciferous sandrock (Beekmantown). Walcott designated it as Chazy limestone in the Bald Mountain section, but stated (1888, page 317) that about 2 miles north of Bald mountain similar rocks contain Trenton fossils. Dale (1889, page 190) also refers to this limestone as Trenton limestone but mentions that in some places it may represent the entire Lower Siluric series and should then be regarded as Trenton, Chazy, and Calciferous. On the Schuylerville quadrangle the limestone is as the above given fossil lists show, throughout of Beekmantown age. There is, however, no doubt that also in other parts of the slate belt limestone of Trenton, or at least Mohawkian, age outcrops. The presence of such

Digitized by Google

is also indicated by the Rysedorph Hill conglomerate, occurring at Bald mountain with its Mohawkian fauna.

The stratigraphic relation of the Bald Mountain limestone to the shales is nowhere apparent, the observed contacts between the two being along fault planes. Thus the limestone is seen to rest by a westerly rising plane on the folded Snake Hill shales below the falls at Middle Falls; since the shales are younger than the limestone, the latter is here overthrust on the shale. The interbedding of shale between the dolomite and shale, assumed in Walcott's Bald Mountain section, is due to a mass of shale folded or thrust locally into the Bald Mountain limestone. The limestone belt is on one side bounded by the shale, on the other by the Georgian rocks; and, as a glance at the map will show, it ends abruptly where the edge of the Georgian overthrust blanket southwest of Louse hill turns east, suggesting that this overthrust mass brought the limestone with it (see postea page 110). We have thus, principally from the fossil evidence, to assume that the Bald Mountain limestone, which surely is older than the Normanskill shale, overlies the Deep Kill shale. But it may come from an entirely different trough or basin, that originally was east of the Levis trough.

RYSEDORPH HILL CONGLOMERATE

Associated with the Bald Mountain limestone in the Bald Mountain section and for 2 miles north of it, occurs a conglomerate of striking character. It is best exposed at the north end of the Bald Mountain quarry, and along the brook skirting the north side of the mountain, below the road. The rock consists of a black mud matrix. In it float without assortment pebbles of all sizes, from that of a pea to those 2 to 3 feet in diameter. The smaller pebbles are well rounded, the larger ones subangular with rounded edges. They are in part the Georgian limestone, but also deep blue dolomite and gray and dove limestones. A few of the pebbles have furnished fragmentary fossils which indicate the Trenton age of these pebbles. The fossils were:

Lingula sp. (fragment)
Siphonotreta cf. minnesotensis *Hall & Clarke*
Rafinesquina sp. (fragment)
Plectambonites pisum *Ruedemann*
Ceraurus cf. pleurexanthemus (*Green*), fragment
Bythocypris cylindrica (*Hall*)
Isochilina armata *Walcott* var. pygmaea *Ruedemann*

Digitized by Google

In the matrix there was also obtained a specimen of Plectambonites pisum, a species known from the Rysedorph Hill conglomerate at Rysedorph hill. As this conglomerate contains pebbles of various ages, from the Georgian to the Mohawkian, like that of Rysedorph hill, and lies in the northern continuation of the latter and apparently, also as this latter, above or in the upper Normanskill shale, we have identified the Bald Mountain conglomerate with the Rysedorph Hill conglomerate.[1] The occurrence of Plectambonites pisum common to both outcrops also supports this view.

We surmise that the Trenton fossils formerly recorded from the limestone north of Bald mountain came from this conglomerate.

The conglomerate at Bald mountain may reach a considerable thickness; in the quarry it is in one place over 20 feet thick, but it is impossible to say how much the folded condition contributes to this thickness. Along the brook northwest of Bald mountain we observed the following section from east to west, the beds being nearly all vertical:

1	Cambric shale	
2	Covered	90 feet
3	Limestone with some quartzite and breccia	55 feet
4	Covered	270 feet
5	Conglomerate with large pebbles Trenton fossils and calcareous matrix Rysedorph Hill conglomerate	45 feet
6	Calcareous shale and shaly nodular limestone (Georgian)	200 feet
7	Covered	70 feet
8	Conglomerate with large pebbles	75 feet
9	Covered	

It is possible that the conglomerate bed in no. 8 is folded upon itself, and in no. 5 the simple thickness of the bed is exposed. It is there about 45 feet thick.

While this conglomerate in its outcrops adjoins the Bald Mountain limestone, its fossils indicate that it is younger than the typical Normanskill shale and intervenes in age between this and the Snake Hill shale. It therefore should be separated from the Bald Mountain limestone by the Normanskill shale. On Rysedorph hill the

[1] Ruedemann, R. Trenton Conglomerate of Rysedorph hill. N. Y. State Mus. Bul. 49, p. 3.

Digitized by Google

conglomerate also outcrops so near the overthrust fault of the Georgian that it might well be a block caught in the fault, although it is there underlain and overlain by shale of presumably Normanskill age. At the Moordener kill a few miles south from Rysedorph hill, it is seen five times repeated in the section and apparently folded in with Normanskill shales 1 to 2 miles away from the overthrust fault. Another fine exposure of this conglomerate which also has furnished Plectambonites pisum is seen in the shore cliffs at Papscanee island, about 5 miles below Albany. This outcrop[1] is at least 2 miles away from the overthrust plane, and another good exposure at Schodack Landing is equally distant. The typical Rysedorph Hill conglomerate southeast of Albany is thus too far away from the thrust fault on which the Georgian was brought westward to be considered as having been brought along this plane, and it is seen in a number of places clearly intercalated in the Normanskill shale as an intraformational conglomerate.

Whatever may be the origin of this remarkable rock, the character and variety of the pebbles and the character of their faunules indicate, as we have shown in the paper on the Rysedorph Hill conglomerate, that they are derived from beds not now exposed in the slate belt and probably brought from the east, especially since the fossils are of Atlantic type. The age of the conglomerate which in museum Bulletin 42 had been held to be lower to middle Trenton, is from the aspect of the faunules of both the youngest pebbles and the matrix, probably greater and corresponding to the Black river. The Normanskill shale with which it is associated in the Rysedorph hill and Moordener kill localities, has been found by Ulrich in the Athens trough to be upper Chazyan in age. We have therefore considered the conglomerate as originally overlying the Normanskill shale and thus represented it in the diagram, text figure 15. Investigations, however, carried on since have brought out the fact that the Normanskill shale embraces two formations, as is more fully stated below (page 93) and that the Rysedorph Hill conglomerate is intercalated in the upper division of Black River age.

The peculiar fauna which was described from this conglomerate by the writer has been recognized in part in the Chambersburg limestone of Pennsylvania of the Chambersburg-Massanutten and

[1] This exposure while then known to the author, was accidentally omitted in Bulletin 42.

Digitized by Google

Plate 12

R. Ruedemann, photo, 1911

View in northern part of western face of Bald Mountain quarry, showing the Bald Mountain limestone, overlain by irregular masses of mylonite or fault-brecciated material and Georgian.

Digitized by Google

Digitized by Google

Plate 13

R. Ruedemann, photo, 1911

View of southern part of western face of Bald Mountain quarry, showing the Bald Mountain limestone overlain by a sheet of mylonite on which in turn rest Georgian rocks that in the quarry, through their red-brown color, contrast more sharply with the black fault-breccia than in the photograph. The uppermost beds of the Bald Mountain limestone are seen to be torn into strings of blocks as if in the process of being incorporated into the breccia.

Digitized by Google

Digitized by Google

Plate 14

R. Ruedemann, photo, 1911

View in the southern face of the Bald Mountain quarry, showing the irregular faulted and broken cliffs of Bald Mountain limestone projecting into a thick mass of mylonite which carries a continuous blanket of much crumpled Georgian grit beds (Bomoseen beds)

Digitized by Google

Digitized by Google

Mercersburg troughs and farther south.[1] Since, however, the Chambersburg limestone does not continue in the Levis trough north of Pennsylvania, the conglomerate can not be referred to as constituting a northern continuation or a part of the Chambersburg limestone and it appears that the Atlantic fauna found in the Rysedorph Hill conglomerate was able to enter the troughs between the Appalachian barriers from the east in several independent places.

The conglomerate about Bald mountain, which is here correlated with the Rysedorph Hill conglomerate is clearly bound to the large overthrust plane, for at Bald mountain itself it is associated with the Bald Mountain limestone, and to the north of it it is even infolded with Georgian shales. As we have already stated, it is here exposed only close to the great overthrust fault and by the latter brought in juxtaposition with the Bald Mountain limestone and Georgian rocks. This position is probably due to its greater resistant power as compared with that of the softer shales, which have been ground up.

Besides this conglomerate, the matrix of which consists, as at Rysedorph hill, largely of sandy lime, there is observed at Bald mountain a breccia of remarkable appearance and thickness. This is seen in plates 12–14 between the Bald Mountain limestone and the Georgian in very irregular masses. It is best exposed on the south face of the quarry, where it reaches 30 feet in thickness in one place and can be easily studied since it descends to the bottom of the quarry. It consists here of an utterly unstratified black mud matrix with numerous unassorted small more or less angular pieces, mostly of the size of a pea or smaller, of limestone, olive grit, chert etc. (see plate 15, which is a photo of a hand specimen). The matrix has the appearance of a thoroughly ground up shale mass and with pebbles floating in it, resembles a tillite. There is, however, no doubt that this mass is the result of the tremendous friction at the base and between the masses of Georgian rocks on top and the Bald Mountain limestone below, which were moved on a nearly horizontal plane. How the top beds of the Bald mountain limestone were torn off and incorporated in the shale is well shown in plate 13, where strings of Bald Mountain limestone are seen to reach into the black mudrock in the process of being torn up. The black soft

[1] Stose, G. W., Mercersburg-Chambersburg folio, Pa. U. S. Geol. Surv., folio 170, 1909. Bassler, R. S., The Cement Resources of Virginia, West of the Blue Ridge. Va. Geol. Surv. Bul. 2, 1909. Ulrich, E. O., Revision of the Paleozoic Systems, pts. 1–3. Geol. Soc. Amer. Bul. v. 22, no. 3. 1911.

Digitized by Google

mudrock is the result of the grinding up of the black Georgian shale and of Snake Hill and Normanskill shales on both sides of the thrust fault.

Törnebohm (1896) has first shown how the rocks are ground into flour along the great overthrust planes. He terms this flour "Friktionsbrei" (mylonite) stating that it served as "Schmiermittel" (lubricating substance) during the overthrusting and that its thickness depends on the obstacles in the mass that is overridden. In the French central plateau these masses are said to reach several hundred meters in thickness.

That in Bald mountain the conditions that rest in the resistance of the underground were especially favorable for the accumulation of the mylonite, is distinctly shown by the bulging up of the Bald mountain limestone mass there, the limestone, together with the overlying Georgian rocks, descending north and south of the face of the Bald mountain quarry, away from the mountain.

THE NORMANSKILL SHALE

This graptolite shale which has received its name from the exposure at the Normans kill at Albany, forms two belts on the Schuylerville quadrangle, one, entirely surrounded by Snake Hill beds, coming up from the Cohoes quadrangle and terminating near the mouth of the Batten kill, and another south of the Georgian overthrust mass, culminating in Willard mountain.

As in the entire shale belt in the Hudson River valley, the greater part of the Normanskill formation consists of blue to gray, mostly argillaceous, often more or less sandy shales, with thin intercalations of black, highly carbonaceous graptolitiferous and frequently pyritiferous shales; the lighter bluish gray and black shales often giving the rock a banded appearance in the common edgewise view.

Where these shales are brought up from such depths that they are still fresh and unaffected by surface weathering and frost, they appear quite different, as more or less compact bluish gray and black mudrocks. Considerable material of this character was seen at the new canal locks above Schuylerville and in other places.

The shales of the Normanskill formation include, however, two other kinds of rock in such quantities that their frequent appearance in outcrops can be considered as quite characteristic of the formation. These are the "white weathering cherty beds" and the grit.

Digitized by Google

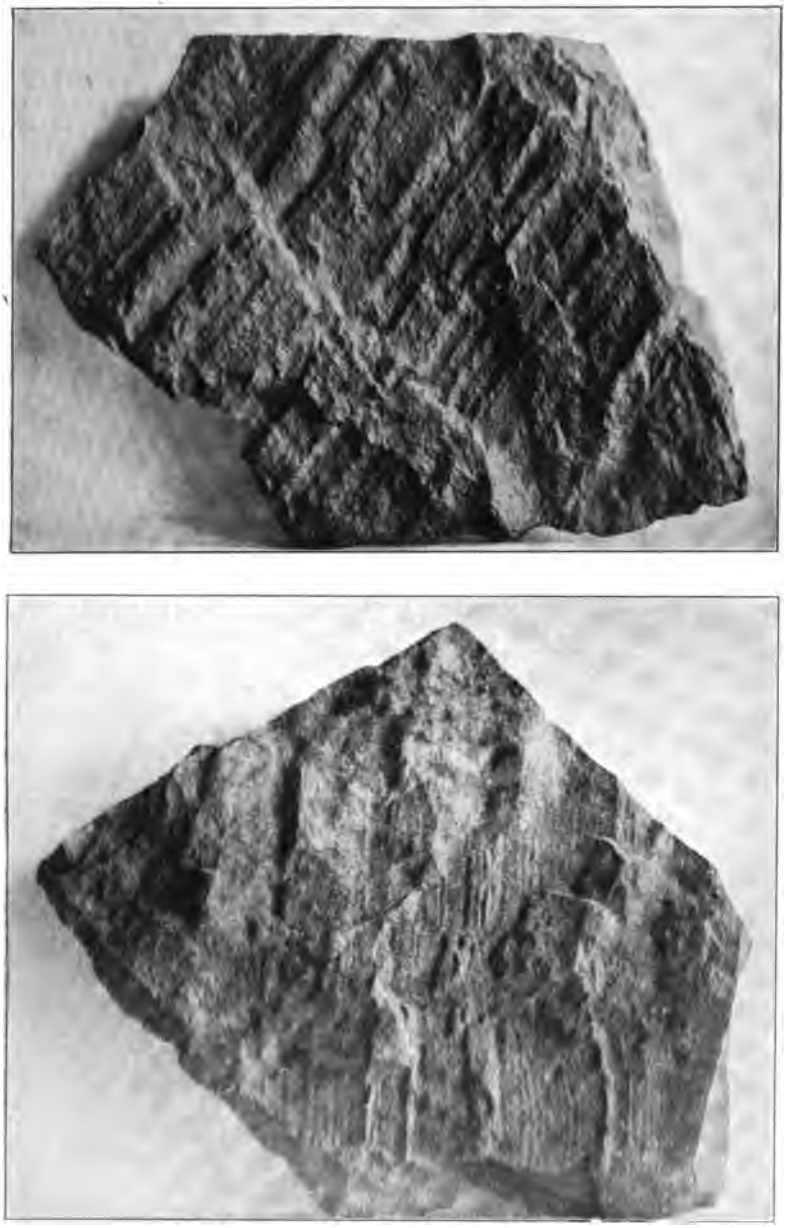
H. P. Whitlock, photo

Hand specimen of mylonite from Bald Mountain quarry, showing the compact structure of the argillaceous matrix, with the numerous small fragments of limestone and dolomite floating in it and seen on the weathered surface. On the left an obscure cleavage is seen. Natural size.

Digitized by Google

Digitized by Google

Plate 16



H. G. Whitlock, photo

Specimen of Lower Cambric rock from the top of the south face of the Bald Mountain quarry. The upper view shows the small slip faults producing offsets on the bedding plane that appear as broader light bands in the photograph.

The lower view shows the other side of the same slab; it is so illuminated that the numerous small ripples parallel with the fault planes are seen. They result from the shoving of the specimen in the overthrusting along a plane oblique to the bedding plane which forms the surface of the slab. Both views reduced one-fifth.

Digitized by Google

Digitized by Google

The white weathering cherty beds. Associated with the black shales of the Normanskill formation occurs a series of very hard, splintery, dark to light greenish or black, cherty-looking beds which weather with very light gray or white crust. These siliceous beds frequently through their greater hardness, stand out as white ridges and form characteristic landmarks. According to Dale (*op. cit.*, page 186) the white surface gives the reaction for kaolinite[1] and the rock was probably originally a feldspathic mud, with quartz fragments and muscovite scales; the latter two appearing under the microscope as the principal constituents of the cherty beds.

The finding of Normanskill graptolites in the white beds at several places on the Schuylerville sheet, notably in a small creek just above Coveville and northeast of Willard mountain, leave no doubt of the Normanskill age of the principal mass of the cherty beds. There is, however, no doubt that similar cherty layers occur also, though rarely, in the Snake Hill formation and that all transitions occur from the common argillaceous shales through slightly more siliceous and whitish weathering shales to the thick-bedded, white-weathering cherty layers.

On account of their great hardness the white beds most frequently form the tops of ridges and can often be traced for some distance along the strike of the folded beds. The more important outcrops of white beds have been indicated on the map by the blue symbols. These show that the principal areas of chert outcrops are the region extending from Coveville northward to Thomson and Northumberland and that of the Willard mountain ridge in the southeast corner of the quadrangle. In the former the most striking chert ridge is seen 1½ miles west of Victory Mills. This forms cliffs seen from the Schuylerville branch of the Fitchburg Railroad, in which are solid beds of the cherty or siliceous rock 30 feet and more thick. Other smaller ridges of white beds protrude through the drift one-half of a mile west of Victory Mills and on the water-swept plateau north of Coveville. Also south and north of the Northumberland plug appear ledges of the harder cherty beds on the hillsides and a small outcrop of very thick-bedded, deep black chert was found just west of the entrance of the Hudson river bridge at Thomson.

[1]According to a later statement by the same author (1904, p. 36) the weathering white of the chert may be due either to the loss of carbon or to the kaolinization of a fine feldspathic cement.

Digitized by Google

The other belt of thick and prominent outcrops of white-weathering cherty beds extends across Willard mountain and forms the backbone or top of the high ridge extending north from Willard mountain, obviously one of the causes that this steep landmark has withstood weathering so much better than the surrounding land. On top of Willard mountain itself, a ridge about 150 feet wide of white-weathering, vertical or steeply inclined synclinal beds is found. The high cliffs on the west brow of Willard mountain consist principally of this chert, which is again finely exposed on the road crossing the ridge north of Willard mountain. It extends here along the crest of the ridge to the north point. Another ledge strikes about a mile east of Willard mountain.

A ridge of white beds begins also north of Snake hill at the shore of Saratoga lake and can be recognized again 2 to 3 miles farther northeast. At the lake shore a solid 3 foot bed of black chert was found intercalated in fissile dark shales. This chert contained Climacograptus bicornis, Glossograptus, Climacograptus modestus, but not the Dicellograptus nicholsoni that occurs all along the lake shore in the shales. It would thus seem to be also of Normanskill age, although it is surrounded by Snake Hill beds. Farther northeast a thickness of over 20 feet of this chert has been observed on top of the ridge.

The graptolites in the chert are not preserved as carbonaceous or pyritized remains as in the argillaceous shales, but are as white as the weathered surface of the rock and, wherever present, show a striking contrast with the dark rock. It is possible that they are also kaolinized, but they may also be composed of the mineral gümbelite, a greenish white silicate which has been found in Bavaria to have sometimes replaced the carbonaceous tests of graptolites.

The Normanskill grit. The white-weathering chert beds are always associated, on the Schuylerville quadrangle at least, with the Normanskill grit. As in the case of the cherty beds, grit beds are also present, though in much less development, in the Snake Hill formation. These grits of both formations have been carefully described as Hudson grit by Dale (1899, page 187), from whom we quote:

> The Hudson grit is a rock so marked in its characteristics as to be easily identified. It is coarse, grayish, sandy looking. Fresh fracture surfaces are very dark and show glistening glassy quartz grains and very

Digitized by Google

frequently minute, pale, greenish, slaty particles. Under the miscroscope, it consists of angular grains of quartz, orthoclase, plagioclase, and scales of muscovite, probably clastic. The cement contains not a little carbonaceous matter, secondary calcite, and pyrite. In the more easterly Ordovician area the cement is quite sericitic and the feldspar is partially sericitized, but in other places and along the Hudson, in Rensselaer county, the amount of sericite in the cement is small. The marked features are the heterogeneity of the fragments, their irregular size, angular outline, and usually the absence of any arrangement in them. Chlorite is rarely present.

A further peculiarity of the Hudson grits is that they contain particles of various fragmental rocks, showing that they were derived from the erosion not only of older granites and gneisses, but of sedimentary rocks of Ordovician or pre-Ordovician age. The particles of clastic rocks were found to consist of shale, micaceous quartzite, calcareous quartzite, limestone or dolomite, slate and flint. The most abundant were found to be quartzite, slate and shale.

Dale recorded the occurrence of graptolites of the Normanskill horizon from the shales interbedded in the Hudson grits.

Like the white beds, the grit beds of the Normanskill shale come to the surface on the Schuylerville quadrangle in two well-circumscribed areas. The grit ledges on this map are denoted by the brown symbol and are crowded in the region west and north of Quaker Springs and about Willard mountain. The former region is one of extremely rough topography, owing to the many broken edges of the grit beds in the closed synclines and anticlines. It is for this reason locally known as "The rocky tucks" and was formerly the site of considerable quarrying for sills and building stone. The ledges are especially well seen in the neighborhood of Quaker Springs. The interbedded shale is but rarely seen, since it usually has weathered back too far and is covered by drift. In one place, at least, we found graptolites of Normanskill type in the interbedded shale. The grit itself is barren of fossils, a few joints of crinoid stems being the only traces of fossils observed.

The belt of grit ledges ends rather abruptly about a mile south of Gates, or 2 miles south of the north bend of Fish creek, not to reappear farther north on the quadrangle.

The second region of grit outcrops is the Willard mountain ridge. As we noted before, the top of this very prominent ridge is formed by the white-weathering cherty beds; the flanks consist, however, of the Normanskill grit. The grit ledges appear very prominently along the lower road west of the mountain. They form considerable cliffs on the northwest side of the Willard ridge and are observable in outcrops and cliffs along the road

Digitized by Google

skirting the eastern foot of the mountain. This belt also terminates abruptly against the Georgian rocks of Louse hill, which have overridden its northern continuation in the over-thrust movement.

The boundaries between the grit zone, shale zone and white-chert bed zone are not sharply delimited, and in one place all three were found to alternate in typical beds several times in a thickness of 17 feet. As the coarse clastic material in the grit indicates, shallow marine conditions prevailed at times during the deposition of the beds and the supply of siliceous and argillaceous mud changed at times very rapidly.

The true stratigraphic relation of the shales, white-weathering beds and grit, owing to the intensely folded and faulted condition of the region, is nowhere shown conclusively. Dale in 1899 (chart facing page 178) gave the following succession in descending order: *Ig* Hudson grits, *Hw* Hudson white beds, *G* Hudson shales; placing the grits on top of the series. In 1904 (page 37) however, he published the following table showing the Hudson formation as exposed in Rensselaer county and the northeastern part of Columbia county, N. Y.:

DESCRIPTION OF STRATA	FAUNA	ESTIMATED THICKNESS IN FEET
1 Black shale with arenaceous limestone (Ruedemann's stations 24–26)	Diplograptus amplexicaulis	1200–2500?
2 Black and gray shale with interbedded grit	Normanskill graptolite fauna	
3 Similar shale with limestone and limestone conglomerate	Trenton fauna in limestone and cement of conglomerate	
4 Black, siliceous, white-weathering, cherty-looking shale	.....	
5 Reddish, purplish, greenish shale with small quartzite bands	.....	

Number 1 are the beds here described as the Snake Hill formation, and no. 3 those here referred to the Rysedorph Hill conglomerate, and placed now, on faunal evidence, above or near the top of the Normanskill beds; while no. 5, the colored shales, are not exposed, if present, on the Schuylerville quadrangle. It will be seen that here the grits are also placed above the white beds. while the dark shales are not recognized as a separate subdivision.

Digitized by Google

It is stated in a footnote that "the vertical relations of the colored shale and the black siliceous shale to each other and to the black and gray shale with Normanskill graptolites are not clear. They are all intimately associated." The same condition prevails farther north in the Schuylerville quadrangle. The facts which are here available for the discussion of the succession of the three divisions are, first, the arrangement in belts from west to east, and second, the structure of Willard mountain. The arrangement of the belts from west to east, with the grits as the westernmost part and the white beds following, would suggest that the grits are the youngest division, since they are nearest to the overlying Snake Hill beds. We have found in general in the shale belt, where larger faults or folds interfere, that the westernmost beds of the same zone are frequently the younger. On the other hand, the Willard mountain ridge is capped by the white beds and the mass of the mountain consists of grits, which dip east on the west side and west on the east side, indicating a more or less complex synclinal structure of the mountain and a normal position of the white beds above the grits.

In weighing the evidence from the two facts, the arrangement of the belts and the Willard mountain section against each other, we incline to consider the latter as nearer the truth, for the abrupt ending of the grit belt near Fish creek proves that the boundary line between the Normanskill and the Snake Hill formations is probably not one of simple succession, but the result of overthrusting and folding, the grit belt being faulted out north of Fish creek. The position of the grit next to the Snake Hill beds is then no evidence for the stratigraphic position of the grit nearest to the Snake Hill formation. Moreover we have good reasons for believing that in the normal succession the Rysedorph Hill conglomerate is located high up in the Normanskill. Its absence near the areal boundary on the quadrangle between the two is then further evidence of the diastrophic rather than stratigraphic character of that line.

We infer from a remark of Dale's[1] that he would have placed

[1] 1899, p. 294. Dale states: "The presence near the base of the Ordovician of a mass of grit containing fragments of slate, limestone and quartzite * * * points plainly to some unconformity at that time. The chief objection to inferring from the particles of clastic rocks in the grits, an unconformity between the Cambrian and Ordovician, is that these grits do not always occur at the contact with undoubted Cambrian rocks."

Digitized by Google

the grit at the base were it not for the fact that it is not always in contact with the Georgian. But this fact, since we now know that the Georgian and the Ordovicic are in many, or all, places separated by an overthrust plane, is no longer of decisive value. On *a priori* ground, since there is an important unconformity in the slate region between the Lower Cambric Georgian rocks and the overlying Ordovicic beds, marking a long period of emergence and erosion, we should expect the Ordovicic series to begin with the coarse grits, these being followed by the fine siliceous muds that produced the white beds, and the latter again by the argillaceous muds that become the dark graptolite shales. This succession agrees with the Willard mountain section and appears to us the true one.

Another question which can not be satisfactorily answered is that of the thickness of the Normanskill formation and of its divisions in this region. Dale, in the above-mentioned table, assigns the "Hudson shales" a thickness of 50+ feet; the "Hudson white beds" 400 feet or less and to the "Hudson grits" 500+ feet; and in a later paper (1904, page 37) the "Hudson formation" of Rensselaer county (including the Snake Hill beds and colored shales) is estimated at 1200 to 2500? feet. A former estimate for the Hudson formation on the east side of the Hudson river by Walcott (1890, page 346) had been 5000 feet. This, as well as Ashburner's estimate of 3500 feet for the Altamont well, are considered by Dale as too high, who holds that "in a region of such moderate relief a mass of beds 2500 feet thick,[1] thrown into small, close and mostly overturned folds, would account for such a rock surface as that depicted in that portion of the map which lies west of the Taconic range." While we agree with Dale in this latter view, we yet consider his estimates as giving the minimal estimates, rather than the maximal ones, for where the succession of faunules permitted the exclusion of the repetition of beds as a factor in increasing the apparent thickness of the formations, considerably greater thicknesses were obtained by the writer. In the case of the Deep Kill graptolite shales of Beekmantown age, for instance, the faunal zones indicate a thickness of the formation of from 200 to 300 feet, while Dale observed not more than 50 feet of this formation in any one place. It is true that Ashburner's measurement of 3500 feet in the Altamont well is not applicable to this shale region, because the shales at Altamont belong in another

[1] Dale's estimate of the combined thickness of the Lower Cambric and Lower Siluric in the slate belt.

Digitized by Google

basin and consist of Canajoharie, Schenectady and Indian Ladder shales. Nor can the great thickness of shales, passed in well-borings in the shale region itself, be considered as demonstrating a great thickness of the shales. In a well at Mechanicville, for instance, 1400 feet of shale were passed without reaching the bottom of the formation; since the shales there, however, are not only dipping at an average angle of about 70°, but also repeated in overturned folds, the thickness of the shale in the well is clearly no indication of a corresponding thickness of the shale beds.

That the possibility exists of great thickness of these shales in this region, however, is shown by the Canajoharie and Schenectady shales in the closely adjoining basin to the west, which were found to reach together more than 3000 feet in thickness.

On the western side of Willard mountain there are exposed about 400 feet of grits, probably without repetition of the beds, a thickness which fairly agrees with Dale's estimate. We would estimate as follows:

Grit	500+ feet
White beds	400± feet
Shale	100± feet

Fauna of the Normanskill beds. Faunules, mainly of graptolites, have been found in many places in the Normanskill belt on the Schuylerville quadrangle. We cite here only the more important occurrences which show the position of the grit, the white beds and shales in the Normanskill formation.

An outcrop of deep black shale, interbedded in the *grit* of the Rocky tucks, about 2 miles north of Quaker Springs, contained:

Corynoides gracilis *Hopkinson*
Didymograptus subtenuis (*Hall*)
Leptograptus *sp.*
Dicranograptus ramosus *Hall*
Climacograptus parvus *Hall*
C. scharenbergi *Lapworth*
Diplograptus cf. acutus *Lapworth*

This is a typical Normanskill association of species.

A six-foot bed of compact black *cherty rock* in a brook just above Coveville contained:

Dicranograptus ramosus *Hall*
Climacograptus parvus *Hall*

Digitized by Google

C. modestus *Ruedemann*
Retiograptus geinitzianus *Hall*

The black shale in a small railroad cut north of the Schuylerville station proved quite fossiliferous.[1] It has furnished:

Corynoides gracilis *Hopkinson*
Didymograptus subtenuis (*Hall*)
Leptograptus flaccidus *mut.* trentonensis *Rued.*
Dicranograptus ramosus *Hall*
Climacograptus bicornis *Hall*
C. parvus *Hall*
Graptospongia pusilla *Ruedemann*[2]
Leptobolus walcotti *Ruedemann*

This shale with its characteristic Normanskill fauna is intercalated in the white beds.

The shale and white beds abutting at the north and south against the Northumberland plug were found to contain Didymograptus sagittarius, showing that the plug is undoubtedly surrounded by Normanskill shale.

The black cherty band at Clarke's Mills mentioned above contains Climacograptus parvus, which also is restricted to the Normanskill shale.

Black shale, associated in the Willard mountain region with the white beds, contains:

Corynoides gracilis *Hopkinson*
Didymograptus sagitticaulis *Gurley*
Dicranograptus ramosus *Hall*
Dicellograptus sextans *Hall*
Cryptograptus tricornis (*Carruthers*)

and the white beds capping this mountain are hence also undoubtedly of Normanskill age.

A good Normanskill fauna was also collected in shales associated with the six-foot bed of chert on the east shore of Saratoga lake, namely:

Corynoides gracilis *Hopkinson*
Dicranograptus ramosus *Hall*

[1] This locality was pointed out to the writer years ago by Prof. J. B. Woodworth.

[2] The originals of this sponge (described in N. Y. State Mus. Mem. 11, 1908, p. 485) came from this locality.

Digitized by Google

D. contortus *Ruedemann*
Climacograptus bicornis *Hall*
C. parvus *Hall*
C. putillus var. eximius *Ruedemann*
Glossograptus ciliatus *Emmons*
Lasiograptus bimucronatus (*Hall*)
Leptobolus *sp.*

Correlation. The writer, finding the Normanskill shale below beds with Diplograptus amplexicaulis, had inferred (1901) that it was at least as old or older than middle Trenton and correlated it with the middle and lower Trenton. It appears now from evidence obtained by Ulrich (op. cit. page 512) in the Athens trough, that the formation is still older and corresponds in age to the upper Chazy. But the Rysedorph Hill conglomerate of Black River age is intercalated in the Normanskill shale in a number of localities, some of which have been cited above (page 82) and to which may be added the fossiliferous exposure of the conglomerate in the big cut of the Boston & Albany Railroad south of Rensselaer.

These militating observations of the Chazy age of the Normanskill shale and of the intercalation of the Rysedorph Hill conglomerate of Black River age, appear to find their solution from observations made lately by the writer, leading to the inference that the Normanskill shale comprises two divisions or formations, the lower of which is of Chazy age and the upper of Black River age and possibly somewhat younger. This upper formation contains the Rysedorph Hill conglomerate. The inference of the subdivision of the Normanskill shale is based partly upon an unmistakable distinction in the graptolite faunules, indicating an older and a later horizon — to be worked out more fully when favorable sections present themselves — and partly upon the observation of traces of other fossils than graptolites and younger than Chazyan in age in the upper Normanskill shale.

SNAKE HILL BEDS

The Snake Hill formation occupies the southeast corner of the Saratoga quadrangle, from Ballston Spa and the Kayaderosseras creek to Saratoga lake. It crosses the Schuylerville quadrangle diagonally as a belt 4 to 5 miles wide, and a second eastern belt follows the Hudson river and unites with the western belt north of the Batten kill. These belts are segments of a greater belt that extends from Pennsylvania through southern New York along the

Digitized by Google

Hudson past Albany and Cohoes on to the Saratoga and Schuylerville quadrangles.

The formation was first distinguished by the writer from the "Hudson River formation" in the neighborhood of Albany (1901) and partly referred to as middle Trenton shale and partly as Utica shale and later correlated with the Magog shale of Canada. Mainly on account of the large and distinguishing faunas obtained around Albany, Green Island and Cohoes, and especially at Snake hill on the shore of Saratoga lake, the formation has recently (1912) been considered as a separate formation by the writer and named the *Snake Hill beds* from the most fossiliferous outcrop.

Lithologically, the formation is similar to the Normanskill beds, but it lacks the strong development of the grits and white beds as distinct divisions, though both are present in thinner intercalations. Besides it possesses a conglomerate with characters peculiar to itself. The preponderating portions of the formation, however, are dark gray to black, bluish and greenish gray argillaceous shales which are difficult of separation from the Normanskill shales, save by the inclosed faunas.

The argillaceous shales prevail so much in the Snake Hill formation that we have not observed in the belt in Albany county any grits and are aware of only one outcrop there with cherty-looking silicious shales. Also on the Schuylerville quadrangle the conglomerate, the grit and the cherty beds have been observed each only in a couple of outcrops, the rest all being soft shale. Thus, the large area in the northeast corner of the sheet, north of Moses kill, which has a rocky surface throughout, consists entirely of shale. The uniform composition of the formation of shale is also well shown in the new barge canal about Fort Miller, where half a mile of rock exposure exhibits nothing but dark gray shales.

Black, carbonaceous, graptolitiferous bands or seams are more frequently found than in the Normanskill shale, but they contain a much impoverished graptolite fauna as compared with that of the Normanskill formation. On the other hand, small lamellibranchs, gastropods, brachiopods and trilobites are frequently seen in the shale, while but traces of such have as yet been observed in the Normanskill shale.

The dark shales contain not infrequently thin, sandy bands and still oftener intercalations of sandy limestones and also gray crystalline limestone, reaching half a foot in thickness. These bands frequently contain a faunule of brachiopods, crinoid joints, etc., and

Digitized by Google

they have furnished the great number of fossils, other than graptolites, recorded by the writer in Bulletin 42. Frequently concretions of both limestone and clay are found scattered or more or less obscurely arranged in layers.

Owing to the extreme pliability of the argillaceous shales and the lack of strengthening intercalations of grits etc., the Snake Hill beds are, as a rule, intricately contorted and crumpled and cut by cleavage planes and smoothed slip planes, until they have the character of the shales which were termed by the geologists of the first survey "glazed" and "semimetamorphic" shales. These shales so designated were Snake Hill shales of the Hudson valley. Yet, localities have been observed, as at the west shore of Saratoga lake, where these shales were distinctly slaty, and near Argyle, just beyond the edge of the sheet, they have been quarried for slate.

At Snake hill — a picturesque high promontory on the east side of Saratoga lake and an old landmark, suspected by many of the settlers of the region of being an "old volcano" — the formation has a different character, the shales containing here compact grit and conglomerate beds 1 to 4 feet thick, consisting of coarse sandstone with silicious and argillaceous cement and many pebbles, up to 1 inch in diameter, well rounded and consisting of shale, black limestone, cherty "white bed" and milky quartz. While the grit and conglomerate beds are bent into recumbent, nearly flat folds, the intercalated shales are intensely crumpled. There also occur thinner beds of gray, crystalline, often sandy limestone. In following the grit beds along the shore it is seen that they are not very extensive, very irregular in thickness and sometimes replaced in a short distance by shale. All the rocks of this locality, the shales, the limestone bands, the grits and the conglomerates, are fossiliferous and besides a few graptolites furnish cystids, crinoids, brachiopods, gastropods, pelecypods and trilobites. In the shore cliffs of the lake a mile north of Snake hill, lamellibranchs and gastropods occur in association with some of the characteristic graptolites of the formation, and in the little disturbed beds of the west shore the graptolites were found in fine preservation in a number of places.

Only one other outcrop of the conglomerate bed was observed, 6 miles northeast of Snake hill. The bed may therefore be lenticular and of but local extent. Intercalations of silicious shales weathering whitish and of sandstone beds were observed in the section exposed along the road leading southeast from Gansevoort

Digitized by Google

to the Hudson river. These were, however, in every case insignificant in thickness and less characteristic in development than those of the Normanskill formation, the thickest sandstone bed measuring but 3 feet.

The Snake hill locality has furnished the following fauna:

Graptolites
- Dicranograptus nicholsoni *Hopkinson*
- Diplograptus (Mesogr.) putillus *Hall*
- Corynoides *sp.*

Crinoidea
- Glyptocrinus *sp.*
- Heterocrinus? gracilis *Hall*
- Cremacrinus *sp.*
- Carabocrinus *cf.* radiatus *Billings*

Cystoidea
- Edrioaster saratogensis *Rued.*

Bryozoa
- Paleschara ulrichi *Rued.*

Brachiopoda
- Schizocrania filosa (*Hall*)
- Plectambonites sericeus typus (*Sowerby*)
- Plectorthis *cf.* whitfieldi (*Winchell*)
- Dalmanella testudinaria (*Dalman*)
- Plaesiomys retrorsa *auct.*
- Rafinesquina alternata (*Emmons*)
- Clitambonites americanus (*Whitfield*)
- Parastrophia hemiplicata *Hall*
- Zygospira recurvirostris (*Hall*)

Pelecypoda
- Whiteavesia cincta *Rued.*
- W. cumingsi *Rued.*
- Orthodesma? subcarinatum *Rued.*
- Whitella elongata *Rued.*
- Clidophorus ventricosus *Rued.*
- C. foerstei *Rued.*
- Ctenodonta levata (*Hall*)
- C. declivis *Rued.*
- C. prosseri *Rued.*
- C. radiata *Rued.*
- C. recta *Rued.*
- C. subcuneata *Rued.*

Digitized by Google

Lyrodesma schucherti *Rued.*
Solenomya? insperata *Rued.*
Cuneamya acutifrons *Ulrich*

Gastropoda

Archinacella orbiculata (*Hall*)
Cyclonema montrealense *Billings*
C. cushingi *Rued.*
Clathrospira subconica *Hall*
Pterotheca *cf.* canaliculata (*Hall*)

Crustacea

Eoharpes ottawensis *Billings*
Trinucleus concentricus (*Eaton*)
Proëtus undulostriatus (*Hall*)
Calymmene senaria *Conrad*
Lepidocoleus jamesi *H. & W.*
Ctenobolbina subrotunda *Rued.*
Technophorus cancellatus *Rued.*

Other localities which deserve notice are:

1 The shore 1 to 2 miles north of Snake hill, where the shales contain:

Dicranograptus nicholsoni *Hopkinson,* abundant
Diplograptus amplexicaulis *var.* pertenuis *Rued.*
D. (Mesograptus) putillus *Hall*
Archinacella orbiculata (*Hall*)
Leptobolus *sp.*

2 West shore of lake (Edgewater Park, Rileys etc.):

Dicranograptus nicholsoni *Hopkinson*
Glossograptus quadrimucronatus *mut.* pertenuis *Rued.*
Diplograptus amplexicaulis *Hall*
D. amplexicaulis *var.* pertenuis *Rued.*
D. (Mesograptus) putillus *Hall*
Climacograptus spiniferus *Rued.*

3 A thin sandstone band in the shale at the foot of the hills east of Moses kill contains:

Schizocrinus *cf.* nodosus *Hall* (joints)
Dalmanella testudinaria (*Dalman*)
Plectambonites sericeus (*Sowerby*)
Rafinesquina alternata (*Emmons*)
Cyclora *cf.* minuta *Hall*

Digitized by Google

Spyroceras bilineatum (*Hall*)
Proëtus undulostriatus (*Hall*)

4 A similar faunule was obtained in a thin limestone band, consisting entirely of shells, intercalated in the shale at the bank of the Hudson river, 2 miles above the mouth of the Snook kill. Here were found:

Glyptocrinus *cf.* decadactylus *Hall* (joints)
Corynoides gracilis *Hopkinson*
Lasiograptus eucharis (*Hall*)
Plectambonites sericeus (*Sowerby*)
Dalmanella testudinaria (*Dalman*)
Trinucleus concentricus (*Eaton*)

Thin limestone bands consisting of shells of Dalmanella and crinoid joints were met with in a number of localities.

5 The black shale brought out of the canal at Fort Miller contains:

Diplograptus amplexicaulis *var.* pertenuis *Rued.*
Diplograptus putillus *Rued.*
Lasiograptus eucharis *Hall*
Leptobolus *cf.* insignis *Hall*
Sandy and calcareous bands
Joints of Schizocrinus nodosus *Hall*
Dalmanella testudinaria (*Dalman*)

The outcrop of black shale below the dam in the Batten kill at Crowe's 1¾ of a mile above Clarke's Mills, contains:

Corynoides gracilis *Hopkinson*
Diplograptus (Mesograptus) putillus *Hall var.*
Diplograptus amplexicaulis *Hall*
and the shale below Middle Falls
Corynoides calicularis *Nicholson*
Diplograptus (Mesograptus) puillus *Hall var.*
Worms (*cf.* Pontobdellopsis cometa *Rued.*)

The localities between the Hudson river and Willard mountain and on the other side of the river have afforded:

Diplograptus amplexicaulis *Hall*
Diplograptus (Mesogr.) putillus *Hall*
Lasiograptus eucharis (*Hall*)
and abundant worms (*cf.* Pontobdellopsis)

Digitized by Google

The fossils which are most frequently met with in the shales are: the graptolites Corynoides gracilis, Dicranograptus nicholsoni, Diplograptus amplexicaulis, D. amplexicaulis var. pertenuis, Climacograptus spiniferus, and the little gastropod Archinacella orbiculata and little lamellibranchs of the genera Clidophorus and Ctenodonta, while the limestone and grit bands contain the brachiopods Dalmanella testudinaria, Plectambonites sericeus, fragments of Rafinesquina and crinoid joints. Rarely a larger fauna of mollusks and trilobites occurs, as at Snake hill, and some places in Albany county. Also worms similar to those described from the Canajoharie shale are frequently seen.

The frequent occurrence of Dicranograptus nicholsoni typus which is not found in the Normanskill shale, appears to us especially characteristic of this formation, especially about Saratoga lake, while Lasiograptus eucharis, which is extremely common in the Canajoharie shale, is here less frequently met with.

Correlation. From the fauna of the Snake Hill beds it can be inferred that the formation is of early Trenton age and roughly corresponds to the lower and perhaps part of the middle Trenton. It probably rests upon the upper division of the Normanskill shale and is the youngest of the rock formations of the Levis basin that by overthrusting and intensive folding have been pushed westward into contact with the formations of the Mohawk-Champlain basin (see diagram, page 140).

STRUCTURAL GEOLOGY OF THE SHALE BELT

BY R. RUEDEMANN

The principal structural feature of the shale belt of the two quadrangles finds its expression in the contrast of the flat-lying or but slightly dipping shales of the western trough and the intensely folded and crumpled condition of all the rocks east of this belt.

The boundary line between the folded and flat shale areas coincides very nearly with that between the Canajoharie and Snake Hill shales, not only on the two quadrangles here described, but in the entire inner lowland extending from the Helderberg cuesta to the Adirondacks and then into the Champlain basin and presumably farther north. It does not coincide exactly because in some

Digitized by Google

regions the folding has transgressed a few miles into the Canajoharie shale area while in others some western marginal cakes of the Snake Hill beds have been left only shattered by fault slips. Thus in Albany county the Canajoharie shale belt striking along the Hudson river has become, partly at least, involved in the folding, while on the Saratoga sheet the Snake Hill shales west of Saratoga lake are only tilted and broken. The boundary between the folded and unfolded areas follows thus on the Schuylerville quadrangle the longer axis of Saratoga lake, being probably in part responsible for the existence of this basin in that place. It thence continues northwest passing west of Kendricks hill where folded Snake Hill shales are exposed. The folded area may also include the last outcrops of Canajoharie shale on the Snook kill below Gansevoort, the shale being there in steeply eastward dipping position.

In general, however, the boundary of the folded and unfolded regions coincides so closely with the Canajoharie-Snake Hill boundary that the proposition of the folding and shoving of the eastern series of shales upon and against the western is well supported by this fact. The crumpling up of a narrow belt of Canajoharie shale in front of the folded area in Albany county on one hand and the shoving westward of a cake of Snake Hill beds without folding (but with much slipping, see below page 103) in Saratoga county on the other hand, both result from the varying resistance offered the oncoming waves of pressure and of folds from the east, through the thickness of the opposing strata and the weight of their covering formations. It appears from the fact that some of the outcrops on the southeast shore of Saratoga lake (on the Cohoes quadrangle) show a great number of closely arranged thrust planes, all rising slightly to the west, that the pushing force in this more or less unfolded western cake was largely spent in overthrusting, this action taking place near the surface under little or no cover.

We have shown before that the Canajoharie and Snake Hill beds belong to different series of rocks, deposited in different basins. Of these the Canajoharie shales have changed their position on the whole only vertically through normal faulting, while the folded shales must have been transported for some distance subhorizontally to come to lie in contact with and partly above the western series. This transportation took place both by folding and overthrust faulting. There is little doubt that the

Digitized by Google

western series has been overridden by the rolling and slipping mass of the eastern shales and grits to an extent at present unknown. We have in the sections extended the Canajoharie shale and the underlying limestones and sandstones to the eastern hill region, because from the thickness of these formations at Saratoga it is sure that they continue for a considerable distance eastward under the crumpled shales. Quite probably they descend gradually eastward under a subhorizontal thrust plane, partly by step faults, such as bring the limestones at Saratoga Springs down to the level of the village (see diagram on left).

The Canajoharie shales of the western belt exhibit but gentle dips in most outcrops. In the region of the Glowegee the dip is to the west toward the fault and to the southwest, while about Saratoga and on the Schuylerville quadrangle it is mostly to the east and southeast, usually less than 5°. Exceptions are the outcrops on the upper Snook kill, at the foot of Mt McGregor, where the dip is on the average 50° and as high as 65°, owing to the nearness of the McGregor fault line that separates the shale and Precambric rocks. At Gansevoort the shale is already much disturbed by slipping and folding, but in general dips steeply southwest, while at Fort Edward, a few miles beyond the limits of the quadrangle, the dip is about 12° to southeast. Both at Gansevoort and Fort Edward a great number of small slips occur, and the varying dip to northwest and southeast indicates that the shale belt is broken into many tilted blocks by faults more or less parallel with the master faults, that is, faults running in southwest-northeast direction. None of these larger faults has been directly observed in the shale. Nevertheless their presence can be directly inferred in several places, as at Rock City Falls and half way between North Wilton and Saratoga Springs, where faults pass from the limestones southwestward into the shales. The fault separating Canajoharie and Snake Hill beds at Ballston may also belong in this class.

Besides these supposed larger faults, a multitude of small slip faults transect the shale. All of these strike northeast, more or less parallel to the master faults, dip slightly to the east and the upthrow side is on the east, all of these faults being of the nature of small overthrusts. The throw is everywhere small, being but a few feet or in some cases only a few inches. Three of them were observed in the lower gorge of the Kayaderosseras, others in the Snook kill near Gansevoort. The best instances of these

Digitized by Google

small overthrusts in the Canajoharie shale occur at the dam at Fort Edward. Here the shale is already somewhat contorted and folds that are inverted to the northwest are exposed. The entire mass of rock is, however, cut by a great number of slip or overthrust faults, dipping southeast at 12° to 14°. The throw is always very small and the thicker and harder beds in the shale are seen to be broken by the slip planes, the upper part being thrust forward a little over the lower, the whole suggesting surface thrusts. These small slips and folds in the eastern margin of the flat shales of the western basin were produced either below the overriding eastern rock masses or in front of them. The step faults prevail therefore in the western part of the belt and the slip faults in the eastern.

At Hudson Falls, a few miles north of the Schuylerville quadrangle, the Canajoharie shale, in being pushed northwestward before the eastern rock masses, appears to have encountered some resistant body which twisted the shales; they are here shattered and filled with a great profusion of calcite veins. It seems as if the spur of limestones and dolomites that protrudes through the shales a mile farther west, at Glens Falls, had been this resistant boss.

Folded area. The structure of the folded area is of the most complex character imaginable. It will be discussed in two parts, (1) the structure of the Ordovicic shale in the Hudson River plain, (2) the structure of the Georgian rocks and associated Ordovicic formations in the eastern (Greenwich) hill region.

The shale belt of the Hudson River plain in the folded area consists principally of the Normanskill shale in the middle and the Snake Hill shale on both sides. This entire mass is uniformly thrown into a mass of closely packed, small closed folds that are asymmetric and uniformly overturned or inverted to the west, so that on the surface and in sections where the tops of the anticlines are eroded away, the entire mass has an isoclinal structure, all beds dipping to the east with varying angles, averaging about 70°. This is especially true where only shales are involved. Where, however, more resistant beds, especially the grit beds, are present, these appear to be folded into less compact or closed folds, and they are liable to form broad open folds in one place and recumbent ones in places near by, as on Snake hill. In the Rocky tucks each leg of the inverted anticline forms, as a rule, a ridge by itself, the roof or top of the anticline being broken out. These

Digitized by Google

small anticlines are mostly of short length, pitching often considerably at the north and south ends. They cause the grit and chert ridges to rise for a short distance above the surface to soon disappear again.

It is probable that also in the Saratoga plain in places a number of smaller anticlines and synclines are combined into larger anticlinoria and synclinoria. At least the presence of a multitude of small grit anticlines in an elliptic space, as in the Rocky tucks, would suggest the probability of such a more complex structure. There is little doubt that anticlinoria and synclinoria exist farther east,[1] where the pushing force was greater and the rocks more resistant, but in this western shale belt the entire crumpled, minutely and often irregularly folded mass has the appearance of a rolling and slipping mass, not strong enough to be thrown into folds of mountain-making magnitude. Yet we find already close to the east, in the hill region, as in Willard mountain, clear evidence of a syncline on such a larger scale.

These folded and crumpled shales are further cut by a very regular cleavage and by faults. The cleavage is ever present in the folded shale region; the cleavage plane dips nearly always to the east, similar to the bedding planes, most frequently intersecting the latter at an acute angle.

While the contorted appearance of the shales in consequence of the many folds often gives the whole mass the appearance of having yielded to the pushing force by simply crumpling up, there is also everywhere evidence of a slipping of the rocks along innumerable slip planes or small thrust faults. We have already mentioned their presence in the eastern portion of the little disturbed Canajoharie shales. In the folded area, however, we have met them everywhere. In the good east-west section, for instance, which the Batten kill furnishes at Clark Mills, a whole series of such faults, about 10 to 20 feet distant from each other, were observed in the north wall and traced across the river bed. They all rise toward the west at angles varying from 20° to 45° and many are made conspicuous by calcite veins. The throw is always small, but the upthrow side is always pushed a little to the west. On the west shore of Saratoga lake where the shale lies in places nearly flat, one overthrust plane was observed that was nearly horizontal; in the cliffs of the southwest shore of the

[1] Dale p. e. has described Mt Greylock as a synclinorium.

Digitized by Google

same lake (on the Schenectady quadrangle) many such overthrust faults were observed; in one place three above each other. They all dip southeast, mostly at an angle of about 25°. Others were observed in the bed of Fish creek at Victory Mills and in road metal pits. In one place, a road metal pit east of Saratoga lake, the slickensides upon the thrust planes, and especially the direction of the slickenside scales, left no doubt that the upthrow side had moved from east to west upon that plane. Some of these overthrust faults have clearly resulted from overturned folds (fold thrusts). The upper leg is seen in such cases to have been pushed westward beyond the lower. Some instructive examples of this were seen about Saratoga lake, especially on Snake hill. Most of these small faults run with the general strike (north-northeast direction) of the beds or are strike faults; some were, however, observed which cut the beds obliquely, as one at Victory Mills, striking N. 60° E. These deviations from the general north-northeast direction are probably connected with local irregularities in the general trend of the folds.

While the throw of each of these overthrust faults is but small, their accumulative effect, going from west to east, owing to their great number and uniform direction of throw, must be quite large. If we assume a throw of 6 inches for each fault and that they are 20 feet apart, we obtain for the belt measured from the foot of Willard mountain normal to the strike, with a width of 10 miles, a compound throw of 1320 feet. The effect of this accumulative throw would be to bring progressively older beds to the surface of the Saratoga plain as one goes east. It is therefore possible that the position of the Normanskill belts to the east of the Snake Hill belts is largely due to this effect of the small numerous overthrust faults which might be termed "*progressive overthrusts.*"

The interesting observations of Woodworth[1] have shown that faulting of "repetitive" character is still going on in the shale belts to the south of the Schuylerville quadrangle and possibly also in the latter. These small faults have also the same northeast strike and where observed, raise the eastern part above the west-

[1] Woodworth, J. B. Postglacial Faults of Eastern New York. N. Y. State Mus. Bul. 107, p. 5, 1907.

Digitized by Google

ern, and may therefore be a continuation to the present day of the "progressive overthrusting" here described.[1]

There is, however, also evidence of possible larger faults, both normal and overthrust, in the folded shales of the Saratoga plain. One larger fault is directly observable at Ballston Spa, separating the Canajoharie shale and Snake Hill beds. This fault is traceable southward through the Ballston lake depression toward the Mohawk river. Its presence is shown by the steep eastward dip of the Snake Hill beds, which rapidly decreases as one goes east, the part of the Snake Hill belt between Ballston Spa and the lake being but little disturbed by crumpling. From present evidence we infer that an important thrust plane separates the Snake Hill and associated now intensely crumpled formations of the eastern basin from the relatively undisturbed Canajoharie shales, along this fault line northeastward beyond the limits of the map. This fault, which is probably a nearly horizontal thrust fault (see diagram), is of the character of a "scission" fault or "charriage." The eastern formations have been pushed westward over this plane for an unknown, but probably considerable, distance. If our conclusion that the Rysedorph Hill conglomerate properly comes in the upper part of the Normanskill shale is correct, then its absence near the boundary line of the two on the Schuylerville quadrangle would also indicate that this line is not one of normal stratigraphic succession, but of diastrophism or movement of the earth crust. As we have shown above, the entire shale belt is transected by a great number of slips or thrusts of small throw, which combined might be competent to bring up the older shales in overlying position to the younger ones; they would, however, not throw the Rysedorph Hill conglomerate out of its supposed normal position near the top of the Normanskill beds.

Whatever the character of the contact along the western edges of the Normanskill areas may be, it seems clear that it is in the nature of an overthrust, either a single large overthrust or a

[1] Woodworth (op. cit. p. 26) is inclined to explain these small faults as step faults with a downthrow to the northwest, which would produce the same effect as an overthrust from the east, and to consider them as part of a tilting of the land in and about the New England district, since the retreat of the Wisconsin sheet, or as resulting from the lifting out of the cores of synclines through lateral pressure from the east. Since the synclines, as a rule, are overturned to the west and compressed into close folds in the shale district, it is improbable that the forcing out of the core of the synclines could be responsible for the numerous small overthrusts observed by us.

Digitized by Google

number of small ones of the character of progressive overthrusts. In the western Normanskill area this is suggested by the pinching out of the grit belt, as stated before, against the western boundary of the area. The line bounding the Willard mountain area of Normanskill rocks on the west is to all appearances of the same character, for this would explain in part that the older Normanskill rocks project here more than 1000 feet above the younger Snake Hill beds adjoining them to the west, and that we find structures, as the cross fold in the southeast corner of the sheet, cut off by that line.

If the eastern Normanskill belt is also overthrust westward, it would seem to have been not only overthrust, but also thrown into the high mountain folds of Willard mountain before the oncoming of the Georgian overthrust waves, for the latter were clearly turned aside by this projecting mass, as shown by the curving strike of the Georgian rocks northeast of Willard mountain. That it still in this late time projects so boldly is of course mainly due to the great hardness of the grit and especially of the white-weathering chert beds which form its backbone.

As far as this relatively small area indicates, we have here a series of successive overthrust masses, producing the intricate structure which in various parts of Europe is known as "Schuppenstruktur," the separate Schuppen being pushed over each other like scales (Schuppen).

While the prevailing material of the rocks that have been overthrusted consists of shales, there are, it appears to us, sufficient masses of solid, hard grit and chert beds in the Normanskill and Snake Hill shales and of limestone and quartzite beds in the Georgian rocks to have transmitted the stress to the shales. Also the compact Bald Mountain limestone and dolomite must have been important agents in the development of the overthrusts. In the Bald mountain section (see page 109 and sections and diagrams in pocket) the limestone is seen to be bounded by overthrust planes from the shales above and below, showing that the shear followed in some places the bedding planes between the limestone and shale, thus separating the two. It is possible that the successive overthrusting took place similarly as suggested by Bailey Willis[1] for the Alpine structure, although we have been led to infer from our observa-

[1] Bailey Willis. Thrusts and Recumbent Folds, a Suggestion Bearing on Alpine Structure. Science, 25:1010.

Digitized by Google

tions that the uppermost thrust plane, that of the Georgian, is the youngest, while Mr Willis considers the lowest, the great major thrust C of his diagram as the youngest.

The appearance of a narrow belt of Schaghticoke shale between Schuylerville and Thomson is evidence of a fault in that section, for since the Schaghticoke is separated by the considerable thickness of Deep Kill shales from the Normanskill shale and these are absent at Schuylerville,[1] a single anticline would not explain the occurrence. It is either a mass, entirely separated from its roots in the contorted and crumpled shale mass, or a small fault block thrust through the other shales. Close by is the "Northumberland volcanic plug," which also is cut by slickensided planes striking in the general direction of the faults of the area; and which, according to Professor Cushing's investigations, may be a similar small block, torn off its main mass and carried forward with the shale masses of the "Decke."[2]

The structure of the Greenwich plateau. The Greenwich plateau enters the Schuylerville quadrangle from the east with a belt only 1 to 2 miles wide. We have to distinguish two structures in the part of the plateau with which we are concerned, namely, the Willard Mountain syncline and the Georgian overthrust mass.

1 *Willard Mountain syncline.* We have mentioned above that the imposing and historic Willard mountain, which rises boldly more than 1200 feet above the bed of the Hudson river, presents the structure of a syncline, much larger and more open than the synclines observed in the shales of the Saratoga plain. This open structure is obviously due to the presence of a great amount of grit and silicious, cherty shale in the strata folded there. At the northeast end the strike of the beds swings around from northeast to northwest, suggesting that the syncline terminates here abruptly with a well-rounded curve. At the eastern foot of the mountain a coarse conglomerate forms the crest of a small anticline.

2 *Georgian overthrust blanket.* If one wanders from the Hudson river, for instance at Thomson or Clark Mills eastward,

[1] We omit here the distant possibility that the Beekmantown beds could be absent in the series at Schuylerville, although it has been claimed that they are intermittent.

[2] Since "blanket" corresponds to the German "Decke" and means *a cover,* relatively thin, such as these thrust masses are, they might be called "thrust blankets." The word "sheet" would be liable to confusion. The French "carriage" is also transferable, although the meaning of the English word carriage for "that which is carried" has become archaic (Webster).

Digitized by Google

one passes in the Hudson River plain over Snake Hill shales, frequently covered by quaternary clays, until near the foot of the hills marking the edge of the Greenwich plateau. Here there is a belt of much broken and distorted Beekmantown limestone (Bald Mountain limestone) and coarse conglomerate (Rysedorph Hill conglomerate), and the hills themselves and the plateau behind them consist of the Georgian rocks. The latter, although immensely older, hold a higher level than the shales west of them. The explanation of this remarkable fact is that the Georgian has been overthrust upon the Ordovicic rocks. This is most clearly shown at Bald mountain where the former quarrying of the limestone at the foot of the mountain has opened a splendid section (see plate of sections).

Bald mountain is, geologically speaking, an historical mountain. It has played a conspicuous rôle in the Taconic controversy and it is therefore proper in this place briefly to review its history. Emmons was the first to direct attention to the Bald Mountain section as being an interesting example in the relative position of the "Taconic" and "Champlainic" (Ordovicic) rocks, that is, as showing the Champlainic rocks as resting unconformably on the Taconic rocks. He gave (1846, page 89) a section through Bald mountain showing the "calciferous sandstone" extending from the top of the mountain to the western foot where it is underlain by the "Taconic" black slates, which also appear on the eastern foot of the mountain. The two trilobites Atops trilineatus and Elliptocephala asaphoides, which demonstrated the actual presence of rocks older than Potsdam in the slate belt, were also cited as coming from the strata "near Bald mountain"[1] (*op. cit.*, page 63).

Walcott (*op. cit.*, page 317) has shown that the complex structural relations of Bald mountain are entirely different from what Emmons supposed them to be. He found Georgian fossils in the limestones, forming the summit of the mountain, and states: "Doctor Emmons identified this mass of strata, *d*, with the calciferous sandrock on lithologic characters, overlooking the fact that a similar rock might occur in his Taconic series." Walcott also recognized the overthrust at Bald mountain. He says: "The section of Bald mountain proves that the strata of the 'Upper

[1] Walcott (*op. cit.*, p. 326) cites them as coming from the black slate 2 miles north of Bald mountain, where Doctor Fitch found them.

Digitized by Google

Taconic' are there pushed over on to the Chazy Terrane, and that the 'Upper Taconic' is not unconformably subjacent to the latter or to the Calciferous sandrock."

The fossiliferous limestone of the downthrow block is Beekmantown; the lower, darker dolomitic beds belong to the same formation with the upper, lighter, purer limestones, being separated at Bald mountain by an inthrust wedge of shale and conglomerate. The black slates which Emmons considered as the Taconic black slates underlying the "calciferous sandrock" are the Snake Hill shales, and his conception of the structure of Bald mountain has thus become completely reversed.

The Bald mountain section is of great interest, not only in regard to the Taconic controversy and the different explanations offered for it, but especially as distinctly showing an overthrust of the Georgian rocks upon the Ordovicic beds and the thrust-shattered condition of all the beds involved in the section. The photographs on plates 12–14 show the limestones much broken by thrust planes auxiliary to the master overthrust, and overlain by masses of mylonite (see page 84) upon which rest the Georgian shale and shaly limestone. There remain standing detached cliffs or blocks consisting of conglomerate and shale on the south side and in front of the quarry, which indicate the former extent of this formation, while to the southwest and west of the quarry there outcrop in several places the dark dolomites (see diagram of front of mountain, plate of sections). It thus appears as if the shales and conglomerates separate the pure limestone above and the dark dolomite below. As we have stated in another place, these two divisions both north and south of Bald mountain grade into each other and form one formation. It is therefore probable that the shales and conglomerate in front of Bald mountain form only a wedge thrust in between the limestones and dolomite.

Dale (*op. cit.*, page 293), from his elaborate investigation of the New York-Vermont slate belt, arrived at the conclusion that the overthrusting at the western margin of the Cambric area is only local in the shale region of New York-Vermont. He says:

> The striking features in all these localities, leaving out the last, are the uniformity of the dip, the great thickness of the Lower Cambrian, and the thrusting over of the latter on the Trenton. These features imply great rigidity in the beds and relief of compression through faulting. These, however, are just the features which are wanting along the slate belt. The

Digitized by Google

Cambrian beds are all in minor folds, as are certainly the several isolated Ordovician areas and the large central ramifying ones. And there is no evidence of such a great overthrust as at Burlington and Saint Albans. But Mr Walcott does find evidence of an overthrust on Bald mountain, in the town of Greenwich, in Washington county, New York, west of the slate belt. The exposures described near North Granville (page 292) also indicate reverse faulting. Yet the course of the Cambro-Ordovician boundary along the western edge of the slate belt, particularly northeast and southwest of North Granville, New York, and in Benson and Hubbardton, Vermont, and again in the townships of Hartford, Argyle, and Hebron, New York, is hardly consistent with the existence there of a great longitudinal overthrust, nor do the vertical relations of the Ordovician and Cambrian outcrops favor such a construction. If such a thrust plane separates the two formations, it must be a folded thrust plane, which is not an ordinary probability.

It would appear, therefore, that the great mid-Silurian orogenic movement which, in northern Vermont, operating upon rigid beds, found relief in a great overthrust, at the south, near the slate belt, operating upon beds which were more plastic, compressed them into minute folds. In either case the compression at the south found relief chiefly in folding, and only here and there, as about North Granville and at Bald mountain, in faulting. But evidences of faulting may be found west of the area here mapped.

In 1901 (page 555ff.) the writer explained the inverted order of the formations observed by him in the neighborhood of Albany by an overturned fold which changed into an overthrust fault, whereby the Georgian became overthrust upon the underturned wing. This view was also reached by Dale in the Geology of the Hudson Valley between the Hoosic and the Kinderhook (1904, page 38). He states: "That the relations on the west side of the Cambrian belt are not only those of unconformable deposition but of more or less continuous overthrust is rendered somewhat probable from the situation of the overthrust near Schodack Landing and of that at Bald mountain in Greenwich, 47 miles north-northeast of the former, as well as from the general direction of the Cambro-Hudson boundary between them. . . . For these reasons it is assumed that in consequence of a westwardly overturned fold, which is frequently ruptured, the Lower Cambrian here usually overlies the Hudson, that is, the Trenton or middle part of the Ordovician."

The subsequent work of the writer seems to indicate that this view as to the origin of the overthrust of the western margin in which he and Dale agree, is the one nearest the truth. We see possible evidence of this hypothesis in the belt of Bald Mountain limestone of Beekmantown age, outcropping below the Georgian

Digitized by Google

along the western edge of the Greenwich plateau. This limestone, which, on account of its Beekmantown age, now recognized, is to be considered as underlying the Snake Hill shale, just below it, may indicate an inverted order below the Georgian, although there is a stronger probability that its presence is due to its having been brought along with the Georgian along the trust plane.

Our observations along the west edge of the Cambric area, not only on the Schuylerville quadrangle but also northward and south of it in Rensselaer and Columbia counties, have led us to the conclusion that we have there precisely that case which Dale considered as not an ordinary probability, and therefore would exclude from his working hypotheses, namely, a folded thrust plane, along which the Georgian rocks have everywhere been overthrust over the Ordovicic rocks. This condition is, in our opinion, a structural feature of the first magnitude of the entire plateau. Likewise the underlying Ordovicic is not only compressed into small folds from the east, but also more or less bodily overthrust over the series of rocks of the Western basin. The same intense pressure which only a few miles farther east caused the regional metamorphism of all these shales, has to be considered as competent to produce the folding and the extensive overthrust faulting.

The facts which induce us to consider the entire western part of the Cambric area at least as overthrust on the Ordovicic rocks, are of both structural and topographic nature. The strike of the Ordovicic rocks in the Saratoga plain leads these rocks directly under the Cambric rocks of the Greenwich plateau, as a glance on the Schuylerville map will show. While from the northeast corner to the foot of Louse hill the Snake Hill beds pass under the Georgian rocks, in the southeast corner of the quadrangle, north and east of Willard mountain, the Normanskill rocks disappear under the Georgian rocks. In several localities where rivers have breached the margin of the Cambric Greenwich plateau, the Ordovicic rocks can be traced upward along the river, forming reentrant angles in the outline of the Cambric. Such a large reentrant or embayment is formed by Moses kill and another broader one by the Batten kill.

Very instructive are the cases of the Hoosic river and Deep kill. At Schaghticoke the Schaghticoke shale (of lowest Ordovicic age) is exposed in the bottom of the river, while the hills to the north and south of the gorge, in the general strike direction of the rocks,

Digitized by Google

consist of Georgian rocks. Likewise at Grant hollow, where the writer found the Deep Kill graptolite fauna in the bottom of the gorge, the tops of the hills on both sides of the gorge are fossiliferous Georgian. The latter occurrence is of great interest because it connects the Ordovicic shale belt, west of the overthrust line, with the large Mt Rafinesque-Rice Mountain "Outlier." If the Georgian rocks overlie the Beekmantown graptolite shale at Grant hollow, it can be inferred that this outlier is really a "Fenster," or a portion of the Ordovicic rocks underlying here the Georgian mass, but exposed by erosion.

There is considerable and quite conclusive evidence that the thrust plane is irregular in its hade, through folding; for while the thrust plane is very slightly inclined at Bald mountain and the Moses kill, it is steep east of Willard mountain, and in the neighborhood of Troy. That these differences are due to folding of a character transversal to the general northeast strike of the beds is indicated by the fact that where the hade is steep, the Georgian rocks descend deeper than where it is flat, as in the valley of the Batten kill, these regions corresponding to depressions or synclines.

There is considerable evidence extant of folding of the entire region long after the Green Mountain revolution, marking the Ordovicic-Siluric boundary, and which is considered responsible for the principal folding and overthrusting of this region. Such later folding is shown by the folded condition of the Rensselaer grit, that is probably of Upper Devonic age, and the remnants of the folded and overthrust Devonic limestones still found along the Hudson river. We have here especially in mind the Kingston region, the folded and overthrust structure of which has been so well worked out by Van Ingen and Clark.[1] These authors have shown there the presence of a practically horizontal overthrust plane, the thrust of which comes from the east and which is possibly a manifestation of the same force that pushed the Georgian rocks over the Ordovicic rocks on the other side of the Hudson.

The question whether the overthrust at the western edge of the Cambric area recognized by both Doctor Dale and the writer, reaches so far back east that the large Georgian area is all over-

[1] Gilbert van Ingen and P. Edwin Clark. Disturbed Fossiliferous Rocks in the Vicinity of Rondout, N. Y. N. Y. State Mus. Bul. 69, p. 1176. 1903.

Digitized by Google

thrust upon Ordovicic rocks as an extensive "carriage," is one that is exceedingly difficult of solution on account of the intensely folded condition of all the rocks involved and this condition is the cause of differences of opinion. We differ from Dale in the eastward extension which in our view this overthrust faulting has attained. We have already above presented evidence that some of the "outliers" of Ordovicic rocks on the Cambric plateau are not such simple outliers, as claimed by Dale, but "Fenster" (windows), that is, portions of the underlying but younger Ordovicic rocks exposed by erosion, and the very small outlier of Ordovicic at Sudbury, under which Dale[1] found Georgian rocks can not be considered as vitiating the other evidence on account of its small size (but 50 square meters) and nearness to a larger Ordovicic body, which suggests that it may be but the remnant of a small infolded mass, such as are apt to occur near the Georgian-Ordovicic boundary on account of the contorted condition of the rocks. Those "Fenster," which we have in view, as especially that connected with the Ordovicic shale belt of the Hudson River plain by the Deep kill gorge (see page 112) lie close to the western edge of the Georgian area, and indicate an overthrust plane as far east as they extend. We see strong evidence for the far eastward extension of the overthrust in the appearance along the western edge of the Georgian area of such rocks as the Bald Mountain limestone, which are totally different from the rocks of the northern trough, and also lacking in the broad belts of shales of the Western trough to the north and south, and which therefore must have been brought a considerable distance from the east, if we will not assume that the limestone was again eroded over most of the area before or during the deposition of the Normanskill shale, an assumption that seems supported by the Rysedorph Hill conglomerate.

The evidence which has been gathered by us in this relatively small area, regarding the overthrust condition of the rocks, is in full accord, as far as it goes, with the views expressed by Ulrich in the Revision of the Paleozoic System, page 442, on the overthrust troughs in eastern New York and western New England.

[1] T. Nelson Dale. The Ordovician Outlier at Hyde Manor in Sudbury, Vt. Am. Jour. Sci., 33:97. 1912.

Digitized by Google

Doctor Ulrich distinguishes five different Eopaleozoic troughs, going east from the Adirondacks, first, the Chazy basin, then the Levis channel, a third trough which contains the marble formation in western Vermont and succeeding limestone and shale formations, and possibly the Lower Cambric (Georgian) deposits. The fourth trough is supposed to have contained the Lower Cambric deposits, and a fifth trough, or rather set of troughs, is thought to be indicated by the highly metamorphosed Paleozoics found to the east of the Lower Cambric outcrops. The evidence on which Ulrich bases his belief in the existence of these troughs is threefold: (1) the differences in fossil contents of the sets of beds; (2) the peculiarities in the succession of the various general types of sediments; and (3) the physical proof of excessive folding and overthrusting.

We have in the two sheets here described undisputable evidence of at least two parallel troughs in the two entirely different sets of formations described above. These are the lower Mohawk trough in the west and the Levis trough in the east. If the Georgian and Bald mountain rocks belong to the third or fourth trough, this is also represented on the map. We have here considered them as underlying the rocks of the Levis trough, as they probably do, at St Albans and Georgia in Vermont (see Ulrich, *op. cit.*, page 493). It can not be doubted that the present position of the Georgian beds on the Schuylerville sheet above the graptolite beds of the Levis channel, and again the position of the latter above the beds of the Western basin require for the explanation of this complicated reversed position under the assumption that they represent but two troughs, a reversed anticlinorium with axial overthrust, as assumed by the writer in a former publication (Bulletin 42), or a complicated system of overthrusts and that the assumption of the original deposition of the Georgian beds in a third trough, which now has become pushed upon the second, will considerably simplify the history of diastrophic processes which have led to the present structure of the region.

The cause of these far-reaching overthrust phenomena which are observed in the whole Appalachian system is the pressure attributed to deep-seated "suboceanic spread" which results from the greater density of the terrestrial crust under the oceanic basins,

Digitized by Google

and which is the cause of the Appalachian and Green Mountain-Taconic fold systems but which also, as Ulrich lucidly shows, causes contraction of these tracts of the eastern continental coast by overthrusting, where deep-seated buttresses, as the Adirondacks are opposed to the folds.

One of the overthrust planes which have been observed on the Schuylerville sheet, namely, that separating the Georgian rocks from the underlying Ordovicic beds, can be traced southward along the western edge of the Georgian to a locality near Schodack Landing, about 15 miles south of Albany, where the Georgian belt terminates near the Hudson. It is now an interesting fact that in the direct southwestward continuation of the overthrust plane similar overthrusts can be observed along which the Siluric and Devonic rocks have been moved westward. Chadwick has described such a fault from Saugerties,[1] about 30 miles southwest from Schodack Landing and between the latter place and the large overthrusts at Rondout, described by van Ingen and Clark. If these overthrusts all belong to the same orogenic movement, the latter is at least of post-Devonic age and probably dates, like all the typical Appalachian orogenic movements, from the close of the Paleozoic era, or is still younger.

THE NORTHUMBERLAND VOLCANIC PLUG

BY H. P. CUSHING

One mile north of the village of Schuylerville, near the Hudson river, is a knob of volcanic or effusive rock of quite exceptional occurrence. Woodworth was the first geologist to recognize its true nature and to describe it.[2] Since 1901, when his study was made, a considerable part of the knob has been quarried away for road metal and other purposes, exposing many features of the occurrence which were not originally visible, and also furnishing comparatively fresh rock for chemical study. The reader can obtain some conception of the differences between the knob as seen in 1901 and as it was ten years later by comparing plates 17 and 18.

Woodworth proposed the name of Stark's knob for this hill. The name is a convenient one, and will be here used in referring to it. Since the appearance of his report, Schuylerville people speak of it as "The volcano."

[1] G. H. Chadwick. Downward Overthust Fault at Saugerties, N. Y. N. Y. State Mus. Bul. 140, p. 157.

[2] N. Y. State Geol. 21st Rept, 1901, p. 117–24.

Digitized by Google

This occurrence of volcanic rock merits detailed description, both because it is unique and because it is puzzling. It is unlike any other known occurrence of igneous rock in the State or in the neighboring states.

Woodworth's original description of the knob is so excellent that we can not do better than to quote freely from it:

The right bank of the Hudson river here consists of the usual bluff of Hudson River slates partly masked by Pleistocene clays. The igneous rock, being more resistant to erosion than the fragile slates, has withstood better the glacial erosion to which the region has been subjected and therefore stands out as a sort of buttress from the main wall of the inner Hudson valley or gorge. Much like the volcanic necks and plugs about Edinburgh in Scotland, this hard mass has been deeply scoured at base on the ice-struck side. In fact, all of the present relief of this plug and the adjacent river valley is due to the action of the river combined with that of the ice sheet of the glacial period.

The summit of the knob scarcely attains the level of the upland which lies west of the river. A slight depression west of the plug serves to give it the appearance of a low knob when viewed from the upland, but at a distance it is relatively inconspicuous. This fact, taken in connection with the dark color of the rock in which respect it closely resembles the adjacent Hudson series, perhaps accounts for its going so long unnoticed or at least undescribed by the geologists who have passed through the upper Hudson valley. There is no mention of the knob by Peter Kalm or later observers; yet it appears from Brandon's historical map of Old Saratoga that General Stark of the American army occupied the eastern base of this knob during the Battle of Saratoga.

Stark's knob igneous mass lies surrounded on the ground by the Hudson River (Normanskill) slates. These are highly inclined, cleaved, and much broken rocks with a general northeast strike. So far as my own observations go, there are no small dikes radiating from the main igneous mass into the adjacent cleaved sedimentary rocks, nor are there any noticeable signs of metamorphism in these rocks attributable to the heating action of the lavas in the plug. The Hudson river group throughout this region is somewhat altered, but not more so at Stark's knob than remote from it. . . . This lack of contact metamorphism, unless such alteration be limited to baking, which was not observed in the accessible portion of the contact, and the failure of apophyses or branching dikes, are points of little value in determining the origin of the igneous rock in the knob. It remains to determine by other evidences whether the rock is intrusive or extrusive.

On the southeast side of the igneous mass and dissecting its border are two faults; that on the eastern side strikes n. 9° e., that on the southeast, n. 54° e. The southeastern fault is downthrown on the northwest, as on this side there is to be seen the slate underlying a mass of trap on the southeast of the fault. The complete relations of the igneous to the sedimentary rocks on this side are not shown. Figure 9, which is a diagrammatic representation of the cross section of the knob and its peculiar internal structure, shows

Digitized by Google

Plate 17

Digitized by Google

Digitized by Google

H. P. Cushing, photo

Stark's knob in 1910 from the southeast. Removal of rock has chiefly been from the south end; on the north it has been stripped though but little has been removed. The arrow points toward the slickensided surfaces and shows the position of the camera for plate 19.

Digitized by Google

Digitized by Google

this fault, but the figure is purposely drawn with some vagueness on the extreme left of the igneous rock.

To sum up the geologic relations of the Stark's knob igneous mass, it is surrounded on all sides by the Hudson river slates. The principal mass is relatively faulted down into these sedimentary rocks on the south and east. To the eye there appears no distinct evidence of contact metamorphism; yet the mass appears to be the superficial portion of a body which extends downward into the slates and, from its general form and surroundings, strongly suggests a neck or plug rising up through the Hudson river group at this point. The manner in which the slate body dips beneath the igneous mass on the northeast, expressed in figure 9, appears to indicate that the neck or plug does not extend vertically downward through the slates but follows guiding planes of structure. It is conceivable that the igneous rock once overlay the surface of the slates, has been tilted with them in one of the orogenic movements of the region, and has subsequently been faulted

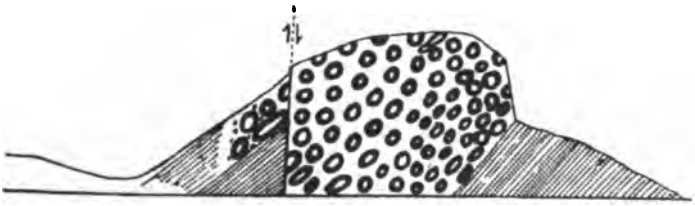


Fig. 9 Cross section of Stark's knob, showing general relation to the slates, and the gross ball structure of the mass

and thus separated from other masses of igneous rock which are now removed by erosion; but this view is not borne out by the observed geologic relations as now exposed.

Structure of the Stark's knob rock. The rock of which Stark's knob is composed is complex in structure. The exposed faces exhibit cross sections of ball and pear-shaped masses embedded in a base having a shaly structure. The crust of these balls consists of a layer of a dense, dark colored basic rock of the diabase type, surrounding a variable nucleus of ashy, rather porous, pumiceous-looking lava in most cases, and more rarely an included marginally absorbed fragment of white, semicrystalline limestone.

The line of demarcation between these three elements in the rock structure is usually very sharp and, where the shaly, fine grained base has peeled away from the surface of the lava balls, the surface of the latter resembles the coarse, bulging flowage surface of basalt streams, such as are seen in Hawaii. The whole has the appearance of a mass of bombs or lava balls inclosing scoriaceous lava, or foreign inclusions embedded in a basaltic glass which has devitrified and is scaling to pieces along lines of flowage. A more probable explanation of the structure is that this mass represents a volcanic throat or plug at some depth below the actual vent or crater but not below the point to which explosive products may have fallen back in the volcano there to become embedded in still hot lava. Certainly the gross structure of the rock recalls many lava sheets with locally formed explosive products, and the same structure is to be observed in the lava flows of the Newark formation

Digitized by Google

of Triassic age in the Connecticut valley[1] (figure 10). The accompanying photograph, plate 17 of the walls of Stark's knob shows the general structure.

The fragment shown in figure 9, lying south of the fault, is more massive than the main stock, and the ground mass approaches more nearly the dense, dark basalt, but here are also developed amygdules.

A hand specimen obtained here displayed fairly coarse crystals of plagioclase, indicative of an intratelluric origin, such as are common in the diabase of many dikes. This combination of the characteristics of dike rocks and of effusive explosive products makes Stark's knob one of the most interesting igneous occurrences, small as it is, within the limits of the State.

Jointing of the lava crusts. The surfaces of the lava balls are beset with a network of cracks perpendicular to the surface. On exposed walls the lava crusts frequently fall to pieces in short, polygonal joint columns similar to basaltic columns.

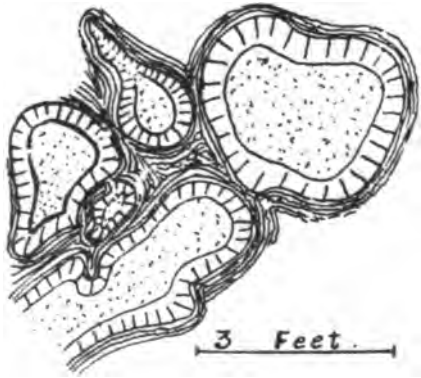


Fig. 10. Sketch of a portion of the western wall of Stark's Knob, showing the gray, scoriaceous interior of the lava balls, the basaltic, jointed crust, and the fissile, devitrified, volcanic glass surrounding the lava balls

The inclusions of limestone point to an irruption through the lower Paleozoic limestones which must occur in this field beneath the Hudson terrane. The inclusions may be appealed to as evidence that the trap came up through the Silurian and subjacent terrane, as held in this paper, and that the rock is not to be regarded as an in-faulted remnant of a lava flow once covering the Hudson terrane in this vicinity.

Since Woodworth's study of the knob, the rock has been utilized for various purposes and largely quarried away. We visited it in 1910, in 1911 and in 1912. In 1910 active quarrying was in progress; in 1911 this was not the case but much material had

[1]Emerson, B. K. Diabase Pitchstone and Mud Enclosures of the Triassic Trap of New England. Geol. Soc. Am. Bul. 1897. 8:59–96. For an illustration of the ball structure at Meriden, Conn., see Davis, W. M., The Lost Volcanoes of Connecticut. Pop. Sci. Mo. 1891, p. 221, fig. 1; U. S. Geol. Sur. 18th Rep't. 1898. pt 2, p. 65.

Digitized by Google

been removed since our previous visit; between this and 1912 yet more was removed, until now comparatively little of the volcanic rock remains above ground. In addition to our own study of the occurrence we have had the advantage of visiting it with other geologists, with Van Ingen and with Smyth in 1910, with Kemp in 1911 and with Woodworth in 1912.

The result of opening up the knob has been to bring to light certain structural features that Woodworth could not possibly have observed in 1901, and to furnish fresher material for microscopic and chemical study than was available to him. Other features showed better on the old, weathered surface of the rock than in the fresher interior.

Constitution of the knob. The knob consists of lava balls, large and small, with intervening material. The balls range up to 2 feet in diameter. At the time of our first visit many of them lay about, being broken up by the quarrymen. In these we were unable to verify Woodworth's observation that they consisted of a dense exterior and more porous nucleus, though these two layers appeared plainly on the weathered surfaces which he saw. A probable reason for this may be that in quarrying, this exterior crust comes away with the intervening matter, leaving the balls free from it. The deforming agencies which have acted upon the knob may well have had this result. The balls, as we saw them, always had slickensided exteriors, and consisted throughout of similar material. Judging from all the data, it seems probable to us that the balls had originally a glassy crust and finely crystalline interior, and that shearing has separated the crust and nucleus so that they do not come away together in quarrying. For the most part the balls consist of dense, black rock, so finely crystalline that crystals are neither visible to the eye nor to the lens. Exteriorly the balls are occasionally amygdaloidal, but there is no great quantity having such texture.

The intervening material has been badly sheared and crushed, so that much of it has the appearance of slickensided, shaly matter. But some of it is less damaged, especially in the vicinity of limestone inclusions, which seem to have acted to prevent crushing; and here the rock is always of glassy texture, a black pitchstone. This is also sometimes amygdaloidal; and this amygdaloidal glass differs so greatly in appearance from the other amygdaloid, that we took it in the field for variolite. This, however, it does not seem to be.

Digitized by Google

The cracks which ramify everywhere through the lava are, for the most part, solidly filled with secondary calcite. The amygdules are chiefly of this mineral also.

Woodworth described coarser grained rock, containing feldspar crystals visible to the eye, from the south end of the knob, and the correctness of the description was verified by Cushing's study of the thin section. But we have been unable to find any rock of this type in our later work. Some rock has been removed from the south end though the original thickness was but slight. None of this coarser material remains and we are left in entire uncertainty as to its original amount.

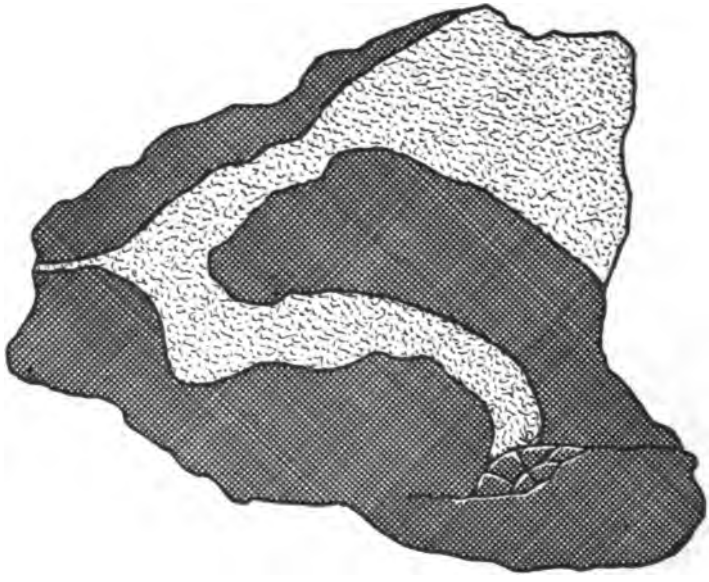


Fig. 11 Natural size drawing of a hand specimen of corroded limestone in pitchstone

The inclusions. Inclusions abound throughout the plug, both in the lava balls and in the intervening material. They are *all* of limestone, and limestone of but a single type. Though the knob stands surrounded by black shales, there are no shale inclusions in it. It is possible that there may be inclusions of earlier trap, and the coarser grained rock just mentioned may be an inclusion. But on this point we have no certain evidence.

The inclusions are of pure limestone, effervescing briskly and immediately with acid. They range in size up to masses a foot

Digitized by Google

or more in diameter. In the balls they show but little sign of corrosive action, but in the glassy, intervening matter they are often considerably corroded by the igneous rock, resulting in the production of most curious shapes (figure 11).

In the specimen figured, the lava attack was probably from the front instead of from the right hand, thus lessening the amount of apparent corrosion, though a large margin remains. These corroded inclusions are in the pitchstone, while those in the balls show but little corrosion and but a trifling selvage of surrounding glass.

The two matters of chief interest concerning the inclusions are, the source of the limestone and the reason for the absence of other inclusions, especially those of shale.

The limestone of these inclusions is slightly reddened, presumably a result of heat from the lava, and is finely crystalline in texture, likely due to recrystallization on heating, though this is not certain. The inclusions are all of the one type of limestone. They must have been brought up from below ground by the rising lava, which must have passed through such a limestone formation during its ascent.

The only rock formation of the region which could have furnished such material is the Bald Mountain limestone of the eastern basin. In the western basin deposits we have the Hoyt and Amsterdam limestones, but they are separated by the great thickness of the Little Falls dolomite. Had the inclusions come from this series there would unquestionably have been an abundance of dolomite fragments in the lava, while actually there are none. But the Bald Mountain limestone has shales above and below. It also has many dolomite beds in its lower portion, so that it is surprising that there are none in the lava, if the inclusions really came from this formation. The question of the source of the inclusions becomes of much importance in the discussion of another problem, and we must later return to it.

The knob is surrounded by black shales, chiefly Normanskill, and it would seem that the lava must have risen through a large thickness of such shale. There are also frequent beds of hard, sandy grit in the shale. Under the circumstances the utter lack of recognizable shale inclusions is most astonishing. There are some large masses of shale involved with the lava but it is questionable if they can be regarded as inclusions. There are a few grains of quartz observable in the thin sections, and one patch

Digitized by Google

consisting of a dozen such grains. It is possible that these came from the grits. But if so, it is surprising that there are not larger fragments from the same source, since these grits are exceedingly tough and well-cemented rocks.

Structural features. The dissection of the knob by quarrying operations has brought to light some new structural features. Woodworth described two faults along the margin of the knob, and his section (figure 9) shows his conception of the relations of lava and shale. But quarrying brought to light other masses of shale, involved with lava, within the knob. We found evidence of severe compressive disturbance and dislocation all through the lava mass of the knob, suggesting a number of minor dislocations throughout the mass, instead of merely the two which

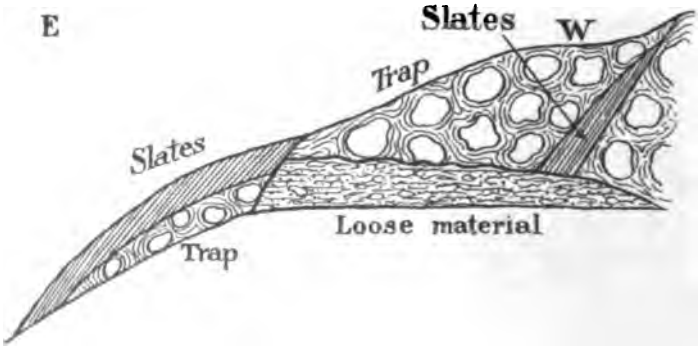


Fig. 12 Sketch of relations of shale and lava near the south end of the knob; shale overlying lava on the projecting point at the left, and a steep shale wedge in the lava midway

he saw, which were all that could have originally been recognized. A few sketches, and a comparison of them with our photograph of the knob (plate 18), will aid in the presentation of the details.

Figure 12 is a diagram of the south end of the quarried face of the knob, with a projecting point on the left which remains unquarried. On that point, slate overlies trap. Woodworth's section, in which trap overlays shale, was made a little farther south, and the remnants may be seen just over the roof of the engine house in plate 18. To the north of the point, shown in the sketch, trap makes the full height of the face and the shale has pinched out, but up this face runs another very steeply inclined, shale wedge, which runs nearly to the top before pinching out. Because of the section which Woodworth saw and figured, he judged a

Digitized by Google

fault must lie between it and the main mass of the knob. But these other shale wedges within the trap mass suggest the query whether the shale in Woodworth's section may not also be a wedge with trap beneath.

At the extreme north edge of the knob is another projecting point, remaining unquarried. A portion of this point is shown at the extreme right in plate 18, though most of it did not get into the view. Figure 13 is a sketch of the relation here.

It is not certain whether the shale here was originally a wedge within the trap, or whether it formed the lower part of the shale cover of the trap on this side, into which a thin sheet of the lava was extruded, or whether it is due simply to dislocation.

The shear zones. In the nearly vertical shale wedge shown at the right in figure 12, the shaly material is greatly sheared and

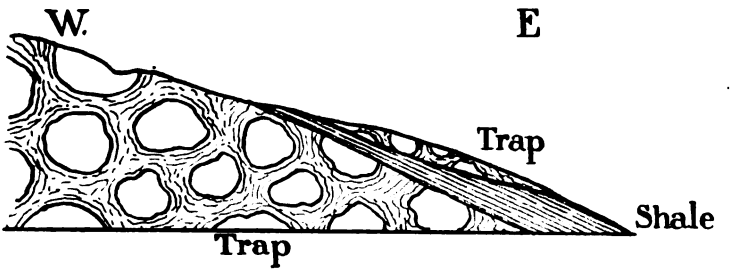


Fig. 13 Sketch of relations of shale and lava on point at the north end of the plug, showing a shale wedge with lava above and below

slickensided, as are also the trap surfaces adjoining the shale. The grooves and scratches on the slickensided surfaces are nearly horizontal in attitude, showing that these two parts of the knob have undergone lateral dislocation along a northwest-southeast line.

Within the northern half of the knob excavation has brought to light another great shear zone, nearly vertical and bearing north-south. There is no shale wedge here along which displacement has taken place, but merely a shearing past each other of the two adjacent parts of the knob, with production of a highly polished and striated contact surface. As in the previous instance, the striae are nearly horizontal, in no observed instance departing more than 20° from it. Here again there has been lateral displacement under conditions of load; in other words, it is inconceivable that these surfaces of hard trap rock could have been so thoroughly smoothed and polished when undergoing lateral slip

Digitized by Google

past one another except under the weight of a considerable thickness of overlying rock.

In addition to these two great zones there are a host of minor shearing planes all through the knob, all showing slickensides on their faces, with usually horizontal striae. The lava balls always show exterior slickensides, and the intervening matter is everywhere greatly sheared.

During 1910 great sheared surfaces became exposed at the base of the excavations in the central part of the knob. The sheared material had considerable thickness and consisted of a mass of shaly, thin plates, with beautifully polished slickensides on all surfaces. The sheared zone had an easterly dip of about 40° and seemed to pass with that inclination entirely through the knob, from bottom to top. It was actually disclosed only for about one-third of the whole height. Plate 19 is a photograph of a portion of this sheared mass, showing the shaly material in considerable thickness. At the time it did not occur to us that this was the actual base of the trap, and we interpreted it as a shear zone within the mass. At subsequent visits it was found covered largely by quarry debris, so that it showed but poorly. We learned, however, that the material had been drilled into for a depth of 12 feet, in search for additional trap underneath, but that none had been found within that distance. This suggests that we have here the actual base of the lava. The material does not exactly resemble the ordinary shale, however, and there is some reason for the belief that it represents a sheared mixture of shale and lava. Here again the striae on the slickensides approach the horizontal.

There is one more indication of dislocation in the knob; its back seems to be broken. This becomes quite evident to the observer on the summit of the knob, looking down into the excavation. The main shear zone in the northern half of the knob trends N. 10° E., which is also the trend of the lava mass there. The southern half, however, trends N. 45° W. and its main shear zone does likewise. The knob appears as if it had been cracked in two midway by a vertical rent, and the two halves twisted out of alinement through an angle of 55°.

All the evidence indicates that the lava of the knob has experienced compressive dislocation of the same type as have the overthrust shales in whose midst it lies; of the same type and quite comparable in amount.

Digitized by Google

Plate 19

H. P. Cushing, photo, 1910

Slickensided shaly material on Stark's knob, as it appeared September 1, 1910. The position of the exposure is shown by the arrow in the previous plate.

Digitized by Google

Digitized by Google

If the great diagonal shear zone just described lies at the actual base of the lava, as we suspect, then the lava forms a short, sheet-like mass inclosed in the shales and dipping in conformity with them, as shown in figure 14.

This corresponds with Woodworth's original conception as may be seen by reference to his figure (figure 9, page 117). The present relief of the knob is due to erosion, the trap being more resistant than the adjacent shales. The shale wedges in the lava may be due to lava tongues running out into the shales from the main mass, or they may be the result of dislocation. There is shearing and faulting in plenty to account for all the observed phenomena.

The lava then seems to lie within the shales after the manner of an intrusive sheet; yet it can not possibly be a sheet. In the first place it is altogether too short. At the north it ends very

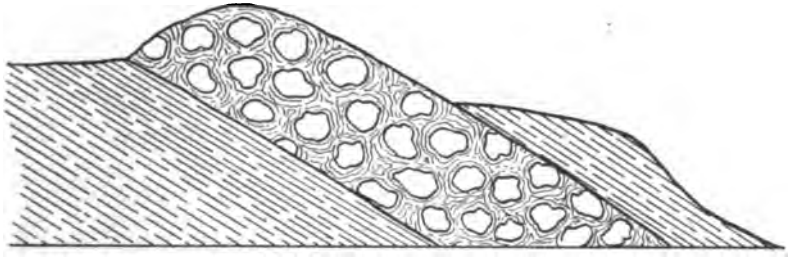


Fig. 14 Diagram of inferred relationship of lava and shales in Stark's knob

abruptly; a trench dug in the rock on the north slope of the knob is entirely in shale. At the south it becomes involved with shale wedges, and just south of the knob a poor exposure shows a thickness of about 1 foot of trap interbedded with the shales nevertheless here also the termination is fairly abrupt. The entire length along the strike from north to south is not over 200 yards. Moreover the nature of the lava itself, the ball structure and intervening glass, decisively negative any notion that we may be dealing with a sheet. The structure indicates surface lava, either a flow or a volcanic neck, a deposit in the throat of a volcano.

Microscopic characters of the lava. There are two chief varieties of the rock of the knob, the finely crystalline, dull, black rock of the balls, and the black glass of the intervening material. Both are locally amygdaloidal, but we saw no such material in place,

Digitized by Google

all coming from the dumps. The study of the exposures has led us to the belief that the balls may have had a glassy crust originally, and that this has been sheared free from them by subsequent movements. At present all glassy material is between the balls and most of it has been much crushed by shearing.

Thin sections from the rock of the balls show a network of minute feldspar laths set in what is certainly in some cases, and probably in all, a glass base. In the finer grained rock from the margins of the balls the laths have a prominent radial or spherulitic arrangement. The somewhat coarser rock from the centers has the same arrangement, but less prominently. The laths are minute and not greatly twinned. In the coarser varieties extinctions up to 20° are shown and the feldspar is probably andesine-labradorite.

In none of the slides is there any determinable pyroxene, nor anything which especially suggests altered pyroxene. In the finer grained rock it is quite certain that no pyroxene ever crystallized out; in the coarser rock some may perhaps have done so, as there are small scattered patches of calcite and possibly alteration products between the feldspars which may have resulted from pyroxene alteration. But we regard it as most probable that the stage of crystallization of pyroxene had not been reached in any of the rock at the time of solidification.

All the slides show occasional, sharply bounded areas which have the outlines of porphyritic crystals. A number of these seem quite certainly original olivines; the outer form and the angles are precisely those of that mineral. This has led to the belief that all are probably original crystals of olivine. They show three different types of alteration.

In type 1 the mineral is entirely gone to a fine, light greenish, feebly polarizing aggregate, which seems unquestionable chlorite. A few individuals show traces of a mesh structure which suggests serpentine, but this is by no means the rule. This is the more usual alteration.

In type 2 the original mineral is entirely replaced by calcite, fairly coarsely crystallized, or else by calcite and quartz. This is the same mineral combination found in the amygdules.

Type 3 is the least common and seems to be a further stage of the alteration shown in type 1. The material is either brown and wholly opaque, or else this with the addition of tiny, colorless patches which show faint double refraction.

Digitized by Google

All the slides contain crystals of black, opaque material. There are occasional small crystals of pyrite. There is much minute, dustlike material, especially in the glass, which may be magnetite, though it wholly lacks metallic luster, perhaps because of its minuteness. There is also much somewhat coarser material, of irregular outline which we should like to identify as graphite. The chemical analysis indicates a large content of carbon in some form, but in reflected light this material does not show a metallic luster such as graphite possesses, but takes on an even, whitish sheen which we are unable to compare with anything we have ever seen in thin section. It seems present in the slides in about the proper quantity to account for the carbon shown by the analysis and may be graphitoid, or some other carbonaceous residue, instead of graphite.

All the slides contain much calcite. It fills the amygdules, it occurs in irregular patches throughout the balls, and it solidly welds up the numerous cracks which run everywhere through the lava.

The calcite in the cracks gives clear evidence of the deformation to which the rock has been subjected since it solidified. It shows everywhere the close-set, multiple twinning, and the undulatory extinction produced by the deforming stresses.

At the borders of the limestone inclusions in the balls a slight chilling effect is manifest, and a narrow zone of glass containing much finely divided, black, opaque matter has developed. A slight amount of corrosion has also occurred, small fragments of the limestone appearing separated from the main mass and in all stages of solution in the lava, the resulting product being a clear, light green glass. Examples of partially corroded limestone surrounded by such glass are shown, together with others which suggest the utter disappearance of the limestone fragments, the glass indicating their original presence. The limestone has also been recrystallized by the action of the lava, the border of the inclusion being more coarsely crystalline than the interior.

The pitchstone which constitutes the intervening material is black, but becomes a clear, light green glass in thin section. It is perfectly clear and unaltered, a matter of some surprise when it is recalled how completely the olivines are altered. Except in the vicinity of limestone inclusions, it has been sheared and shows its condition of strain by being doubly refracting. It is locally

Digitized by Google

packed with tiny opaque inclusions, perhaps magnetite, shows an occasional pyrite crystal, and frequent irregularly bounded individuals of the material that we are assuming to be graphitic. At the contacts with limestone inclusions, clear evidence of limestone absorption is shown by the production of a zone of mingled material, calcite and glass, the relative proportions of which vary with distance from the contact. The glass is lighter in color and no longer clear glass, but full of very tiny crystals, often spherulitic, which are altogether too tiny for exact determination, but which appear to be feldspar. The addition of lime to the melt seems to have lowered the temperature of solidification sufficiently to permit at least the beginning of feldspar crystallization, while elsewhere the material solidified as glass. This intermediate zone is unquestionably one produced by direct solvent attack of the lava upon the limestone, and is thus corroborative of the evidence of this attack previously given.

The amygdules in the glass have the appearance of small, round, black bodies, when whole; when broken across, the interior filling is light colored but dull looking and not so white as in the case of the amygdules in the balls. The filling is the same in both cases, either wholly calcite, or else calcite with some quartz, both of fairly coarse grain.

Chemical composition. Since the rock from the centers of the large lava balls seemed in quite fresh and unaltered condition, except for the olivine, it was confidently expected that a chemical analysis would definitely show the composition of the lava, and would be attended by no especial difficulty. But analysis developed the presence of a considerable amount of carbon in the rock, rendering determination of ferrous iron very difficult, and showed also the presence of a large quantity of water. This also was difficult of exact determination. But Professor Morley has labored indefatigably at the problem. The ferrous iron was finally determined by bichromate titration. Professor Morley states that the results can not be vouched for to the single drop, as with permanganate, but that the uncertainty is not great; that he can not hope that the accuracy of the three determinations, Fe_2O_3, FeO and H_2O+ is as great as that of the others but that he has every reason to believe in their reasonable accuracy. Our indebtedness to him for the painstaking labor and the eventual very satisfactory result is most emphatically expressed.

Digitized by Google

The water is no doubt present as a constituent of the glass. The interest attaching to the presence of carbon more than compensates for the slight uncertainty introduced into the analysis.

SiO_2	47.55
Al_2O_3	16.65
Fe_2O_3	4.94
FeO	5.12
MgO	5.63
CaO	4.77
Na_2O	4.20
K_2O	2.52
H_2O+	5.57
H_2O-	0.24
TiO_2	0.87
P_2O_5	0.27
Cl	0.10
F	0.06
S	0.01
MnO	0.46
C	0.80
$CaCO_3$	0.34
Total	100.10

Selected rock from the center of one of the large lava balls, as free as possible from calcite. E. W. Morley, analyst.

The calculated norm of the rock would be

Orthoclase	15.01	Olivine	12.64
Albite	33.01	Magnetite	7.19
Anorthite	18.90	Ilmenite	1.67
Nepheline	1.42	Apatite	0.67
Diopside	2.48		

Totalling 92.99 per cent; the residue consisting of water, carbon and calcium carbonate. The rock classifies in

Class 2, Dosalane	Rang 3, Andase
Order 5, Germanare	Subrang 4, Andose.

It is thus a member of a very large rock group, of diabasic or basaltic composition. It is quite near some of the Newark traps, that from Medford, Mass., analyzed by Merrill for example, though it is a more basic rock than the average Newark traps, which run from 52 to 53 per cent of silica.

Digitized by Google

The carbon[1] content was a wholly unexpected result. Gaseous compounds of carbon are emitted by most cooling lavas, but a considerable carbon content in the cold lava is most exceptional. Inquiry as to its source is naturally suggested.

The knob is surrounded by black shales, which at once suggest themselves as a possible source. There are no recognizable shale inclusions in the lava, but it might be possible that the explosive action of the eruption should have mingled a certain content of comminuted shale with it. The thin sections however give no suggestion of any such admixture, no shale particles being recognizable in them. And when it is recalled that, in such black shales, the entire content of carbonaceous matter does not usually exceed 5 per cent of the rock, it will be seen that the rock at the knob would of necessity contain from 15 to 20 per cent of shale, in order to give the carbon percentage shown on analysis, provided it came from this source. But neither the thin section, nor the chemical analysis give any suggestion of such an admixture.

A trifling amount of carbon may have been obtained from dissolved limestone, as this contains a small amount of organic matter; and the abundant opaque particles developed in the glass at the limestone contacts, definitely suggests something of the sort. But there is no evidence of a large amount of limestone corrosion, and the rock is low in lime, rather than high. It could not have obtained much carbon from this source.

There remain apparently two possible sources for the carbon. The heat of the intrusion may have liberated hydrocarbons from the shales below ground, which were then taken up by the lava, or the lava itself may have contained more carbon than usual originally, more than could be oxydized by the usual volcanic processes. Either process is unusual, but then the occurrence is itself unusual. Graphite does occur in igneous rocks, as for example in some of the Adirondack pegmatites. Its occurrence in meteorites is well

[1] Because of the interest attaching to the presence of carbon in an igneous rock, Dr H. S. Washington kindly volunteered to look over the thin sections, and to examine the insoluble black residues of the rock. In a letter received from him too late for incorporation in this report he states that the material is carbon, and is not graphite. He also makes the following suggestion to account for its presence, that it is not impossible that, under proper conditions of pressure and temperature, FeO will reduce Co^2. He calls attention to the limestone inclusions as the source of the, CO^2, and notes that the carbon in the thin sections is in the glass, and not in the feldspars, hence associated with the iron-bearing portion of the rock.

Digitized by Google

known. It is quite possible therefore that it is here one of the primary minerals of the lava. But the comparatively large amount present, together with the rarity of its occurrence in igneous rocks, enforces caution in attributing such a source to it. In so far as possible derivation from the shale is concerned it must be stated that the associated shales in the vicinity of the knob show no indication of any loss of carbon due to action of the lava, or indeed of any change whatever, so that if we look to them as a source we must assume that the process only took place at greater depths. It would be a debatable question whether hydrocarbons, liberated from the shales by the heat of the intrusion, would migrate into the lava; whether they would not rather be driven away from it. Even if taken up why should they have been converted to graphite? All, or nearly all lavas contain carbon; but on cooling they give it off in combination with oxygen, or with hydrogen. Why an exception was made in this case we cannot say.

Is the lava in place? Stark's knob is a small mass of igneous rock inclosed in shales. The shales are greatly contorted and compressed everywhere, and the evidence, both structural and paleontologic, shows that they have been overthrust into the district from the east. The question naturally arises, May not the igneous rock have come into the region by overthrusting, along with the inclosing shales? We regret that we are unable definitely to answer this question. Were it true, certain of the structural features would receive a simple explanation. The shearing and dislocation of the rock would thus be accounted for, as well as its abrupt termination laterally, and the lack of dikes running out from it into the shales. We could understand the reason for the shale wedges inclosed in the lava. More latitude would be given in accounting for the inclusions, abundance of limestone of a single type and absence of all other rocks. The manner of occurrence in the shales, a short and comparatively thick mass of lava imprisoned in shales along their dip, would also not be so hard to understand. The shales are so cleaved that they usually come apart more readily on the cleavage planes than on the stratification. It is this character that makes it so difficult to collect fossils from them. It would seem that the explosive action of a volcanic vent breaking through them would have opened them vertically along the cleavage planes instead of following the incline of the dip.

Digitized by Google

If the lava solidified where it now rests, the only possible conception of the occurrence which at all fits the facts of the case is that it is a volcanic neck. But volcanic necks are usually nearly vertical, instead of quite inclined, as in this case; they usually cut across the bedding instead of following it; and they are usually filled with agglomerate, tuff or solid lava. We do not recall any account of a volcanic neck filled with material such as that at Stark's knob. The usual filling is generally much more distinctly fragmental in type and more diversified in character. On the other hand, we know of no reason why such material might not accumulate in a neck.

Many features of the rock of the knob recall very forcibly the characters of pillow lavas, characters produced (in many instances at least) in surface lavas when poured out so that they mingle with surface waters. Spheroidal masses of lava, production of glass, and explosive mixture with fragmental material from beneath, are the prominent characters of such lava flows. A great number of shrinkage cracks through the lava pillows is another feature possessed in common.

At Stark's knob there is no sign of the basal admixture with fragmental material, such as is found in many pillow lavas, unless indeed the shear zone material at the base may represent it, crushed beyond recognition, as an analysis perhaps suggests. Nor is the lava as highly altered as most pillow lavas are; yet this difference may be more apparent than real. Most such have been described from natural exposures, and exteriorly the rock at the knob was highly altered. The fresh material is due to quarrying and comes from many feet below the original surface.

Nor is the structure exactly comparable with that of pillow lavas, the chief difference being in the greater quantity of intervening material at the knob. We have seen that shearing has probably increased the apparent amount of this, the outer portions of the balls cracking and shearing away, especially where composed of glass. But when every allowance has been made for this it remains doubtful whether the balls were ever as closely packed and close fitting as in most pillow lavas.

In weighing the evidence for or against the lava being in place, with part of the evidence seeming to point one way and part the other, we must confess our inability to come to any definite conclusion in the matter. The overthrusting seems a p r i o r i so unlikely that our sympathies are entirely with the other view. But

Digitized by Google

we can not relieve ourselves of the suspicion that it may, after all, be an overthrust mass, a fragment of a surface flow which came up through and was poured out upon a surface of limestone, thus acquiring its inclusions, and later on thrust westward coming to rest with rocks with which it had originally little to do.

The inclusions. The difficulty of accounting for the limestone inclusions in the lava has already been mentioned. The inclusions are many, and all of one kind of rock, which seems perhaps referable to the Bald Mountain limestone, but certainly to no other of the rock formations of the region. The knob lies in the midst of overthrust shales. Just what their thickness is at the spot we have no means of knowing; but it is quite likely considerable, since they extend 5 miles farther west before thinning out to disappearance. In considering the manner of overthrusting in such weak shales it seems reasonable, if not obligatory, to suppose that the thrust was carried by some strong, competent stratum, on top of which the shales were carried westward. The Bald Mountain limestone is the first formation of the sort beneath the Normanskill shale, in the eastern basin section, and it is therefore not unreasonable to suppose that it is present underneath the shales at Stark's knob. If so it probably rests on the western basin rocks, most likely on Canajoharie shale. That the structure as a whole is not so simple as this, that the shales are jumbled indiscriminately together to a certain extent, is shown by the presence of Schaghticoke (Dictyonema) shale in the midst of the Normanskill near the knob. Were fossils more abundant, many such mixtures might be found. This suggests that a confused mixture of shales may have moved west even beyond the competent stratum which carried them, falling and being pushed in front of the main mass. The Bald Mountain limestone therefore may, or may not, be present below ground at the knob. If it is present it lies nearer the surface than any other limestone, with shales both above and below; and it is likely also to be in somewhat shattered condition, so that it would readily furnish inclusions to an igneous rock rising through it. The limestone inclusions can therefore be plausibly accounted for on the theory that the lava is in place. The lack of inclusions of shale is not thus explained; but the carbon content of the lava may have come from the shale, and its failure to furnish inclusions may be due to the physical nature of the rock.

So far as the inclusions are concerned, therefore, they do not aid in the decision as to whether the lava is in place or is not.

Digitized by Google

If the drill should show that the Bald Mountain limestone was absent below ground at the knob, a quite different face would be put upon the matter. But the drill has not been at work in the vicinity.

The age of the lava. Since the suggestion was made that the igneous rock of the knob might have some significance in connection with the theory of the juvenile origin of the Saratoga waters, the question of the geologic age of the rock becomes of more moment than would otherwise be the case. Unfortunately precise data are quite lacking.

When Woodworth and Cushing considered this matter, at the time of the original description of the knob, a Newark (Triassic) age was suggested by each of them, independently, as most probable. Then, as now, the only positive statement that could be made is that the igneous rock must be younger than the shales which surround it. Even this is not necessarily true, if it has been overthrust. The shales are of Ordovicic age. There are known in New York three groups of igneous rocks which fulfil that age requirement, the dikes of the Champlain valley, the dikes of central New York, and the traps of the Newark series. The rock, in its characters, does not at all suggest the Champlain dikes; still less does it in any way resemble the peridotites of central New York; but it is quite similar to some phases of the Newark traps. Unless we referred it to the Newark we had no alternative but to regard it as representing igneous action of some other date, with no other known representatives in the State.

That still seems to us the most logical view to take in default of actual evidence to the contrary. The amount of deformation experienced by the knob seems a positive evidence of antiquity. The dislocations already described indicate deformation under load, under a considerable thickness of overlying rock which has since been eroded. The lava is of the effusive type, either a volcanic neck or a fragment of a lava flow. Since its formation it has been buried under other rock, deformed, and the overlying material removed by erosion. When or under what it was buried we have no means of knowing, since all trace of the material has since been removed; but if the lava is in place, continental deposits of Newark age seems the most likely supposition. It might have been later continental deposits. To be sure, the knob lies in a main valley of erosion surrounded by relatively weak rocks, so that conditions are favorable to rapid wear. But even making

Digitized by Google

every allowance for that it still seems to us that the very oldest Tertiary is the youngest age that can possibly be ascribed to the rock, all the conditions considered. Since igneous action of such age, or of any Tertiary age, is wholly unknown in the eastern United States, a reference to the Newark seems to us more reasonable. Yet we candidly admit the peculiarity of the rock and its isolated occurrence, and have no quarrel with anyone who is disposed to take a different view. There is one character of the lava which suggests recency, and that is the unaltered and undevitrified character of the glass.

To sum up, the only definite statement that can be made concerning the knob is that it consists of a small mass of lava of effusive type. If it is in place it seems surely a volcanic neck or throat; if not in place it may be a fragment of a surface flow, overthrust from some locality to the east. If in place it is younger than the date of the overthrusting; if not in place it is older. If not in place we have no idea whence it came, nor are any other fragments known. It has some features in common with certain Newark trap flows and is like some of them in composition, though the composition differs from that of the average Newark trap. Clear structural evidence of much shearing and faulting of the knob, of such type as to indicate deformation under load, leads to the conviction that the lava can not be an especially recent one.

HISTORICAL GEOLOGY

BY H. P. CUSHING AND R. RUEDEMANN

Precambric. Our direct knowledge of the events of Precambric time in the region commences with the deposition of the Grenville series. These rocks are very widespread and very thick, with great amounts of shales and limestones and a lesser amount of sandstone. They must have been deposited on some floor of older rocks which has since been entirely destroyed by igneous action, or else yet remains to be discovered. Judging by their extent and thickness the series was probably deposited under marine conditions but, lacking fossils, there can be no certainty in the matter.

Following the deposit of the Grenville sediments the region was repeatedly invaded from beneath by great masses of igneous rock. The earliest and most widespread of these invasions was that of the Laurentian granite. Subsequently came invasions of anorthosite, syenite, granite and gabbro. These broke up the Grenville rocks into groups of fragments, apparently ate away and digested much

Digitized by Google

of the basal portion of the sediments and caused the complete disappearance of their old floor of deposit.

There followed a very long period of erosion of the region during which it was above sea level. A great thickness of rock was worn away from the surface, bringing to daylight the tops of the great igneous masses which originally solidified much below the surface. The final effect of the long erosion period was to have reduced the entire region to one of low altitude and small relief. Toward the close of this erosion period renewed igneous activity resulted in the formation of the trap dikes.

Paleozoic history. The Adirondack region then developed a tendency to dome upwards centrally and to sag at the margins. These sagging margins passed from time to time beneath sea level and received accumulations of deposit. In these troughs the early Paleozoic sediments of the region were laid down. Oscillations of level were of frequent occurrence, accompanied by warping of the region. Submergence in the different troughs alternated; it was the rare exception that all were depressed at the same time. In this report the deposits of the Champlain-Hudson trough (the so-called "Chazy basin") chiefly concern us.

To the eastward of the Chazy basin downwarping developed one or more other troughs, in which deposits quite different from those of the Chazy basin were laid down. Since their formation these rocks have been overthrust to the west upon the rocks of the Chazy basin, and directly adjoin them upon the east.

CAMBRIC HISTORY

Chazy basin deposits. Potsdam sandstone. The first Paleozoic deposit of the Adirondack margins was the Potsdam sandstone, an accumulation of coarse, quartzose sands and gravels. The accumulation began first on the northeast, in Clinton county, and extended itself progressively to the west and to the south. Only the upper portion of the formation is found in the Saratoga region.

This upper portion contains marine fossils and must have been laid down in shallow marine waters. But marine fossils are lacking in the lower half of the formation, in Clinton county, and many of its characters suggest that it was laid down above sea level instead of below it. They suggest also that the climate was arid. But whether marine or not, the accumulation began because the district sagged down. This sagging began at the north and slowly

Digitized by Google

extended southward up the Champlain trough, and westward up the St Lawrence trough.

The currents which transported these coarse sands and gravels must have been vigorous ones, suggesting rather strong relief of the land which lay to the south and west. All fine material was washed and blown to a distance.

The sands of the Potsdam are succeeded by the alternating sands and dolomites of the Theresa formation without any sign of a break between them. Erosion had lowered the bordering lands. Sand came down only intermittently and in less volume, and beds of dolomite began to be deposited. The sands steadily diminish in frequency and thickness, and thus the Theresa formation grades upward into the Little Falls dolomite. Both these formations are marine, but in both of them fossils are very rare, especially in the dolomite. The great reefs of Cryptozoon, which occur at many horizons, seem to indicate the likelihood of abundant life and to suggest that the scarcity of fossils is more likely due to unfavorable conditions for preservation than to their absence in the marine waters.

The Hoyt limestone is a local upper phase of the Theresa formation about Saratoga. It seems to represent a more offshore phase of the formation, and fossils are much more abundant than in the ordinary Theresa or the Little Falls dolomite. This may in part be due to the offshore character of the Hoyt, but it also suggests more favorable conditions of preservation.

These three formations are of extreme upper Cambric age (Ulrich would class them as Ozarkic), and are the only Cambric deposits that were laid down along the Champlain trough. Following their deposit mild uplift occurred and the troughs came above sea level, existed as land for a space, and were somewhat eroded. This erosion gently bevelled off the surface instead of deeply cutting into it. which suggests that the land was of low altitude.

ORDOVICIC HISTORY

The uplift just mentioned forms for the geologist the dividing plane between the New York Cambric formations and those classed as of Ordovicic age. No one has any clear idea in regard to the length of elapsed time which this uplift represents. Eventually the troughs became again depressed and occupied by marine waters; and in these, on all four sides of the Adirondack region, the various

Digitized by Google

dolomite and limestone formations of the Beekmantown group were laid down. These are thickest and most complete in the Champlain trough which sagged more, and for a longer time, than the troughs on the other three sides of the Adirondacks. But the Beekmantown deposits of the Champlain trough do not occur in the Saratoga region, and hence do not especially concern us in this report. The Saratoga district is on the western margin of the trough, its axis lying to the eastward. The trough was submerged and emerged several times. The waters of some of the submergences overspread the Saratoga region, as in the case of the Little Falls submergence; but the others failed to reach the district. Apparently the Beekmantown waters fell just short of covering it. It is barely possible that the formation was thinly deposited and subsequently entirely worn away. Beekmantown rocks do not appear in the Saratoga section.

Emergence of all troughs followed the Beekmantown, the emergence being of unknown duration. Then the Champlain trough was depressed so that its northern portion passed below sea level and the marine limestones of the Chazy group were laid down. This depression seems not to have reached within 75 miles of the Saratoga region which remained persistently as an area of lowland throughout Beekmantown and Chazy time.

BLACK RIVER HISTORY

Apparently emergence of all troughs followed upon the Chazy depression. Because the immediate Saratoga region lacks deposits of Beekmantown and Chazy age, these episodes have been described as though each consisted of a single submergence and emergence. In reality minor oscillations of level took place within both groups. Depression of the troughs, in which the various formations of the Black River group were laid down, succeeded the Chazy emergence. In order of age the three chief formations of the Black River group are the Lowville, the Watertown, and the Amsterdam. Only the near shore edges of these formations are now exposed to view in New York. They are very patchy in distribution and were deposited along the oscillating margins of the troughs, now above sea level, now below. The thicker deposits of the central portions of the troughs are not shown in surface exposures today, but lie farther away from the Adirondacks, buried under a cover of later rocks.

Digitized by Google

The Amsterdam is the only Black River formation deposited over the Saratoga region. The margins of the Lowville and Watertown troughs did not quite reach the district, and the Amsterdam rests on the Little Falls dolomite. It is the oldest Ordovicic formation of the quadrangle. Between the deposition of the two the region stood as a land area on the margin of the Champlain trough. The small amount of erosion of the Little Falls surface during this long interval is indicative of low altitude of the land.

The pure limestone of the Amsterdam denotes also low altitude of the neighboring land. The abundance of marine fossils shows plentiful life in the waters.

Uplift followed Amsterdam deposition, the Saratoga region passing slightly above sea level.

Succeeding this uplift came the Trenton submergence. At first, beds of limestone and of blackish shale alternated with one another; but the limestone soon ceased and the great thickness of the Canajoharie shale of lower Trenton age slowly accumulated in the subsiding trough. The fossils are chiefly graptolites; open sea forms swept into the trough by marine currents which ran through it. Conditions were not favorable for an abundant and diversified marine fauna.

During this same time Trenton limestones were being deposited on the west side of the Adirondacks, in clearer seas which swarmed with marine organisms. Conditions on the two sides of the region were thus sharply contrasted.

In middle Trenton time the deeper Canajoharie sea which extended from the Mohawk valley northward through the Chazy–Saratoga basin into Canada and southward through the Hudson river region and as far south as the southern Appalachians, was probably drained for a brief period in this region, but soon again the shallow sea of the Schenectady period extended through the trough northward to an unknown extent, but undoubtedly across the Saratoga and Schuylerville quadrangles. The bottom of this trough kept sinking gradually, so that upward of 2000 feet of shallow water deposits could be accumulated in it in Schoharie and Schenectady counties.

In the following Utica period this region was probably again emerged, for no Utica deposits have as yet been recognized in the lower Mohawk and Hudson valleys, the so-called Utica beds of these regions all being now known to be of Canajoharie age. It

Digitized by Google

is, however, also possible that a thin edge of the Utica formation reached here around the southern Adirondacks, but was again eroded before the Indian Ladder sea crept over this region from the south. This latter formation consists, at the Indian Ladder, mainly of soft shales with some sandstone and calcareous bands, and seems to have been deposited in a slightly deeper sea than the Schenectady beds.

As we have seen before, there are exposed in the shale belt rocks of two entirely different sets of formations which represent sedi-

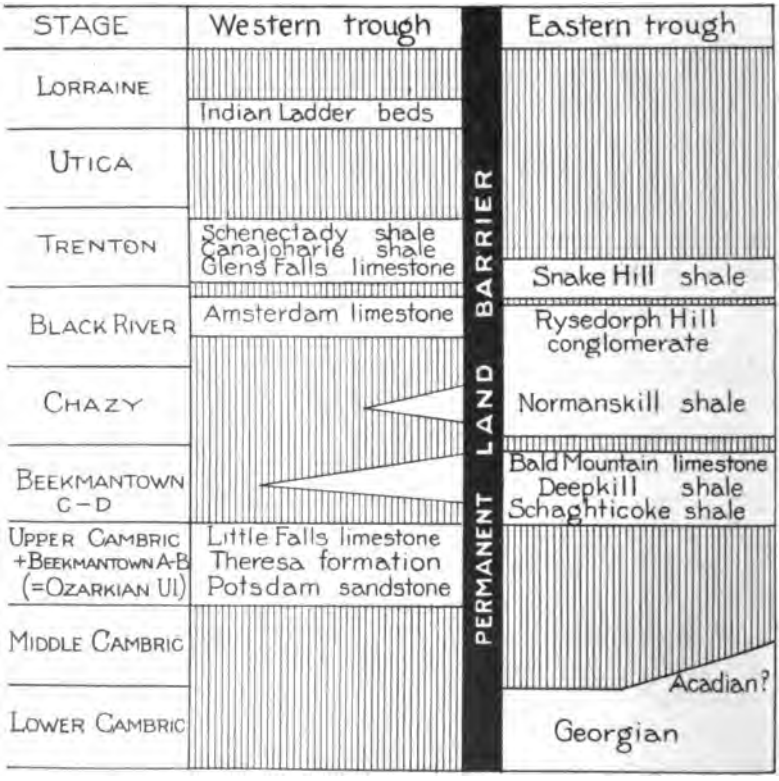


Fig. 15 Diagram of time relations of formations of the eastern and western troughs on the Saratoga-Schuylerville quadrangles. Shaded intervals indicate probable emergences

ments deposited in two different troughs, the western or lower Mohawk trough and the eastern or Levis trough; and if the Georgian beds represent a third trough (see above, page 114), even sediments of three basins.

Digitized by Google

We have represented in figure 15 the events going on in the two troughs, as far as the Saratoga and Schuylerville quadrangles are concerned, during Cambric and Ordovicic time, where the shaded periods represent emergences and the unshaded the submergences. It is seen at once that frequent oscillations took place in both basins and that the invasions of the sea and withdrawals did not take place simultaneously in both basins, but at very different times and apparently independently of each other. It appears, however, that there is recognizable a certain approximate alternation of the invasions of the sea in the two basins, indicating an east-west shifting of the seas in the troughs, such as has been observed in more complete development by Ulrich (1911, page 543) in the Ordovicic seas of the Appalachian valley troughs in east Tennessee. Moreover, the invasions came partly from the northeast or Atlantic basin and partly from the Gulf and Pacific basins.

The Lower and Middle Cambric time finds the western trough entirely drained of the sea, while at the same time a great mass of sediments was deposited to the east, the Georgian in the Levis trough, and the Acadian in still more easterly troughs, and possibly also to a limited extent in the Levis trough. This invasion came from the north.

In the Upper Cambric the scene of submergence shifted entirely into the neighboring westerly trough, where invasions first from the north and then from the southwest brought the Potsdam sandstone, the Hoyt limestone and Little Falls dolomite, while the eastern trough or Levis basin was at the same time raised above sea level.

During Beekmantown and Chazy time that part of the western trough now exposed was apparently drained in the area of the two quadrangles here described, the rocks of the two formations being absent between the Little Falls dolomite and the Amsterdam limestone. They are, however, present but a short distance north in the Ticonderoga-Crown Point region, and the sea in both the Beekmantown and Chazy times, nearly reached the quadrangles in this basin from the north, or it actually reached there in the more eastern, deeper parts of the trough which are now buried under the overthrust shales of the eastern trough. The sea did reach into this latitude and beyond, coming from the north, in the Levis trough, where the Schaghticoke and Deep Kill graptolite shales and possibly also the Bald Mountain limestone

Digitized by Google

of upper Beekmantown age were deposited in Beekmantown time; and after a brief emergence, the Normanskill shale of Chazy age, which in its turn was followed after another short emergence by the sea depositing the Upper Normanskill shale with the Rysedorph Hill conglomerate and the Snake Hill shale. It appears that this whole group of Ordovicic seas of the Levis trough invaded from the north. The north connection is shown by the faunas and areal distribution of the Schaghticoke, Deep Kill and Normanskill shales, by the Atlantic faunas of the Rysedorph Hill conglomerate, and it is suggested by the fauna of the Snake Hill shale. Some of these, as the Deep Kill and Normanskill seas, had also connection with the Pacific ocean.

LATER PALEOZOIC HISTORY

Withdrawal of marine waters from the Saratoga region followed the deposit of the Indian Ladder shales and for the latter part of the Ordovicic period the region was above water. Then followed a time of considerable disturbance and uplift, the so-called Taconic revolution. Along a belt of country east of Saratoga the Ordovicic rocks were folded and upturned. About Saratoga this disturbance had no effect beyond giving the region somewhat increased altitude. During the following Paleozoic periods, Siluric, Devonic etc., the region continued its oscillations of level, but the times of depression did not carry the bottoms of the troughs below sea level. Paleozoic rocks younger than the Ordovicic, and all Mesozoic rocks, are absent from the western trough. It remained a trough during all this great lapse of time, but it remained above the level of the sea, even when its altitude was the lowest. Siluric and Devonic seas came into southern New York, but probably the waters of none of them covered Saratoga.

Apparently, however, the district remained at low altitude during all this time. No great thickness of Ordovicic rocks has been eroded from its surface. These shales of the upper Ordovicic are weak rocks and would be readily worn away under conditions of high altitude and free drainage. That they remain in such thickness as they have over so much of the district is demonstrative of small erosion since they were laid down.

It is quite probable that during oscillations which depressed the western trough, continental deposits accumulated in it and were subsequently worn away during the intervening periods of greater altitude. It is also possible that the overthrust shales of the more

Digitized by Google

easterly troughs may have formerly extended farther west than they do now, and have covered the present exposures of the rocks of the western trough, from which they were afterward worn away. But this does not alter the fact that the Ordovicic shales are the last marine deposits known to have been deposited in the region; that the time which has elapsed since the close of the Ordovicic is enormously long; and that it seems inconceivable that these shales could remain over so much of the district and in such thickness, if the trough had ever had a high altitude for any considerable length of time.

CLOSING STAGE OF THE PALEOZOIC

It has long been held by geologists that the closing stages of the Paleozoic were, in eastern North America, a time of great earth disturbance. The district was uplifted and titled and at the same time the rocks were greatly folded and faulted by compressive forces. Folded rocks characterize the Appalachian district from Alabama to New York, and thence northeast to Gaspé.

It is quite certain that widespread uplift and Appalachian folding occurred at this time; but it would seem also that the preliminary stages of the folding, at least, had taken place long before. The sagging troughs of which we have been speaking, separated from one another by tracts of relative uplift, were the initial stages of this folding, which had been in progress all through the Paleozoic, as recently urged by Ulrich.[1]

The Paleozoic deposits of the lower Mohawk trough, the Western basin deposits of this report, were for some reason not greatly folded. They lie nearly flat today. They lay either too far west or without the zone of folding; or else the unyielding mass of the Adirondacks, which lay back of them, acted to prevent folding.

Did the thrust faulting which has carried the rocks of the Eastern basin into our district take place at this time, or not till later? We can not positively answer this question as yet; but we are in agreement with Ulrich in thinking that much of it is of later date and possibly very much later.

MESOZOIC HISTORY

During the entire Mesozoic the Saratoga region remained a land area. During the earlier portion of the time certain troughs along the east margin of the Appalachian region subsided and received a

[1].Geol. Soc. Am. Bul., *22*:436–42.

Digitized by Google

large thickness of continental deposits. There is no vestige of such deposits in the lower Mohawk trough, and no direct evidence that they were ever deposited there. That a small thickness of such material may have been laid down in the trough at this date is by no means unlikely. The lower Mohawk trough, throughout its history, has had a tendency to sag, as contrasted with the territory east and west of it. It would not be forced or unnatural to assume that it participated somewhat in the sagging tendency which was so prominently manifest in some neighboring troughs to the east and south at this time. But if such deposits were formed here they were in such slight thickness that every vestige of them has since been removed by erosion.

When were the great faults of the eastern Adirondack region formed? And was the faulting wholly done during one single period of disturbance, or has repeated dislocation occurred along them since they were first formed?

The repeated sags of the western trough would tend to form fault breaks along its margins, separating it from the adjacent districts, the Adirondack region on the west for example, whose tendency has been to rise rather than to sag. It is therefore quite possible that faulting began in the district early in the Paleozoic. With every notable succeeding oscillation of level of the region it is highly probable that renewed faulting would take place along the breaks already in existence. Such an oscillation as that which brought the Paleozoic to a close would be sure to be accompanied by renewed movement along the fault planes.

The early Mesozoic rocks of the easterly Appalachian troughs have been greatly faulted since they were laid down. Obviously this faulting must be of later date than the deposition of the rocks. Most probably also this faulting was not confined to the mere troughs of deposit, but affected the adjacent territory also. It seems in the highest degree likely that further faulting occurred in the Champlain region at this time. The faults of the eastern Adirondack region are normal with nearly vertical fault planes, and these certain Mesozoic faults are of similar type.

On the other hand, the great overthrusts which have carried the rocks of the eastern basin west to their present position, covering much of the Schuylerville quadrangle, are faults of an entirely different type. The question arises as to the relative age of the two types of faulting. If the thrust faulting occurred before the normal faulting it would seem that the thrust-faulted territory

Digitized by Google

should be also sliced by big normal faults. So far as we know, this is not the case. If on the other hand the thrust faulting is of a later date than the normal faulting, the overthrust materials should rest on a floor composed of the rocks of the western basin, these latter cut by normal faults which do not rise into the overlying, overthrust rocks.

We do not as yet possess decisive evidence on these points. Such as we do have, however, seems to indicate that, in the Saratoga region, the bulk of the thrust faulting is of later date than the normal faulting.

Cessation of the continental deposits of early Mesozoic age in the eastern troughs was probably brought about by renewed uplift. Then followed a long period of erosion whose final result was a rather thorough wearing down of the region to a comparatively level plain. Such an erosion plain is called a peneplain; a peneplain of this date was produced quite generally throughout the Appalachian region and eastern Canada, and it is reasonable to assume that it was also produced here.

CENOZOIC HISTORY

At the close of the Mesozoic the region was again uplifted. The low altitude peneplain which had been produced over the Adirondack region was elevated some 1500 feet or more, and rapid erosion of its surface began. Stream valleys were cut down and broadened. It is the depth of the valley cutting below the old peneplain level which enables us to estimate the amount of the uplift. The divides between the valleys, however, have been but little worn down during the time that has passed since the uplift. These divides rise now to uniform levels, the levels of the old peneplain. An observer, standing upon one of these divide summits and looking abroad to the others, receives the impression of standing upon the surface of a plain and has merely to imagine the valleys refilled with material in order to picture the plain as it was at the time of the uplift.

This old peneplained surface is readily made out over most of the Adirondack region. But in the extreme east it seems to fail and the divide summits rise to very discordant levels instead of being uniform. This we take to mean that here renewed slipping along the old faults occurred as a phase of the uplift; that the Champlain trough displayed anew its tendency to sag relative to

Digitized by Google

the district to the west; that it was uplifted much less than the Adirondacks; and that the difference in amount was made possible by additional faulting, the easterly slices being thrown down relative to those west of them. The old fault scarps had been peneplained, along with the rest of the region. These further movements renewed them, and their prominence today is in part due to this late movement. The McGregor and Hoffman fronts of the Saratoga quadrangle would be much less imposing than they are had it not been for this.

It is by no means unlikely that further westward movement of the eastern basin rocks along the thrust fault planes also took place at this time.

During the first part of the Cenozoic, the Tertiary, minor oscillations of level took place in the region, but we lack the precise knowledge of just when and what they were. The close of the Tertiary was a time of additional uplift, considerably increasing the altitude of the region, not improbably with renewed faulting. Succeeding this the region was invaded by the ice sheets of the glacial period.

PLEISTOCENE HISTORY[1]

Judging from the glacial history of other parts of North America, the Saratoga region was probably covered by four or five successive ice sheets, which extended south from Labrador and occupied the territory. It was certainly occupied by two such sheets. Long interglacial periods intervened between these ice sheets. The glaciers interrupted the drainage, eroded the region somewhat, and on retreat left it cumbered with glacial deposits.

There were also oscillations of level during the glacial period, with loss of the initial high altitude. At the time of retreat of the last ice sheet the altitude of the region was lower than at present.

During the slow, northward retreat of the last ice sheet through the Hudson and Champlain valleys, various bodies of standing water occupied parts of the valley, south of the ice. The most southerly of these, and the one of greatest importance in the history of the Saratoga region, is known as Lake Albany. This was a fresh-water lake which extended as far south as Kingston

[1] Two forthcoming reports by Professors Woodworth and Stoller on the Pleistocene of the Schuylerville and Saratoga quadrangles respectively will furnish full treatment of this portion of the geological history of the region.

Digitized by Google

Plate 20

H. P. Cushing, photo, 1910

Glacial boulder of Little Falls dolomite on the summit of a low drumloid hill, 3 miles west of Saratoga. The boulder stands on end and from a distance bears a strong resemblance to a monument shaft.

Digitized by Google

Digitized by Google

and, at its greatest extent, perhaps as far north as Whitehall. Fine clays were deposited in its waters and huge sand deltas were built along its shores by the streams which flowed into it. The great terraces of clay and sand which occur both east and west of the Hudson on the Saratoga and Schuylerville quadrangles, were laid down in its waters.

Lake Albany was succeeded by Lake Vermont. The latter lay, for the most part, north of the Saratoga region, in which its deposits are of little importance. In the Champlain valley its waters were lower than those of Lake Albany.

When the ice finally melted out of the Champlain valley the altitude was so much lower than now that the whole of the valley, and of the St Lawrence valley up to Lake Ontario, was below sea level and hence became occupied by marine waters. The whole Champlain-Hudson trough, however, was not thus depressed, Woodworth pointing out that the marine level probably did not reach south of Whitehall. Passing down Lake Champlain the marine beaches, and the marine fossils contained in the deposits, are found at steadily higher altitudes going north. At Plattsburg the marine waters reached a level some 300 feet above the present level of the lake. Woodworth does not believe that the trough south of Whitehall was submerged at this time. The trough seems to have oscillated on a pivot, depresssion at the north being coincident with elevation at the south, and vice versa. The pivotal line lies in the district between Whitehall and Albany. Since the ice vanished, the northern district has been steadily rising, the marine waters have been excluded from the Champlain and the upper St Lawrence valleys, and the St Lawrence estuary now ends at Montreal. This upward movement is likely still continuing. At the same time the lower Hudson valley seems to have been undergoing depression and its estuary lengthening. The Saratoga region is near the pivotal line and probably has been but little affected by these movements.

We can not leave Pleistocene matters without calling attention to one detail, the impressive glacial boulder shown in plate 20. It stands on the summit of a low drumlin, 3 miles due west from Saratoga, and is a conspicuous object. Viewed from a distance it looks like a monument, a simple shaft. It consists of a huge slab of Little Falls dolomite about 15 feet long, stood up on end. Some exfoliation has taken place, due to frost attack, but on the whole it has suffered comparatively little damage from the

Digitized by Google

weather. For the glacier to leave a block of such shape in such position in such a commanding situation is highly exceptional, and it is one of the most striking objects of the kind that we have had the privilege of becoming acquainted with.

ECONOMIC GEOLOGY

BY H. P. CUSHING

Molding sand. There is a large annual output of molding sand from the general Hudson river region in New York, especially from the vicinity of Albany. The Schuylerville quadrangle makes a considerable contribution to this output, the material coming from near the surface, just underneath the soil. The sand forms part of the deposits of Lake Albany, which cover most of the surface below the 300 foot level on the Schuylerville quadrangle. For foundry purposes a sand must have a certain degree of refractoriness, cohesiveness, and porosity. Durability is also important, as is texture, but sands of considerable difference in size of grain may be used, the coarser for one kind of castings and the finer for another. The cohesiveness results from the sand occurring mixed with a certain percentage of clayey matter.

The deposits of molding sand have no great thickness, running from 8 or 9 inches up to a few feet thick. They commonly pass into worthless sand below. Good natural molding sands are not very common, so that the demand rather exceeds the supply.

Graphite. Mining for graphite has been carried on at two different localities on the Saratoga quadrangle, both of them quite recent projects. The older and larger of the two establishments is situated about 2 miles west of Porter Corners on the fault plane scarp of the Hoffmans fault. The other is 4 miles north of Saratoga Springs, and similarly situated on the McGregor fault plane scarp. The rock is quite similar at the two localities and seems to represent the same horizon in the Grenville series, a horizon in the quartzite formation. At the time of our study only the establishment at Porter Corners, the Empire Graphite Company, was in operation.

The Grenville beds at this locality have a N. 70° E. strike and a dip of from 30° to 50° to the south. The surface beds are soft and badly altered graphite and mica schists. They are quartz-feldspar-graphite and quartz-feldspar-phlogopite rocks, averaging 50 per cent quartz, 30 to 40 per cent of feldspar and the remainder

Digitized by Google

a varying mixture of graphite and phlogopite with some apatite. The feldspars are so badly altered as to defy exact determination, but in part at least consist of plagioclase, likely oligoclase. Two beds are being utilized, or are capable of utilization, because of high graphite and low mica content. The upper bed, from 10 to 14 feet thick, has been the one chiefly worked up to date. The lower bed is much thinner. They are separated by a four-foot thickness of quartzite and thin limestone. Underneath is a much more solid bed of mica gneiss. The whole overlies massive quartzite and, like all the Grenville of the quadrangle, is more or less involved with the white, garnet-bearing granite which we regard as Laurentian. There has been an irregular output of graphite by this company since 1906, the production being exclusively flake graphite.

Much the same assemblage of rocks is shown at the pit of the Saratoga Graphite Company, but this is a newer enterprise with much less accomplished in the way of exploitation. Similar weak, altered schists are shown, of the same mineralogic make-up as at Porter Corners. We saw no rock so free from mica as are the two beds worked by the Empire company, though further exploration may disclose equally good material. The strike here is N 80° E, and 30° south dip, and the general similarity of the rock association strongly suggests that we are dealing with the same rock horizon.

Stone quarries. Quarries have been opened in several of the formations of the two quadrangles, in the Precambric granite and trap, in the Little Falls dolomite, the Amsterdam limestone, the Bald Mountain limestone, and the Northumberland volcanic plug.

Laurentian granite. A small quarry has been opened in the Laurentian white granite on the face of the McGregor fault plane scarp, 2 miles north of Saratoga. Like all the granite of the district it contains Grenville material in all stages of absorption. But the quantity of such inclusions of schist is much less here than elsewhere, the granite is massive and solid and of pleasing color, and there seems no reason why it should not make a most excellent structural material for many purposes. The location, however, is unfortunate, the quarry being situated well up the steep slope of the fault plane scarp, rendering cartage difficult and expensive.

Trap. A large quarry has been opened on one of the large diabase dikes where it is crossed by the North Creek branch of

Digitized by Google

the railroad, 2 miles north of Saratoga. This dike is at least 100 feet wide on the average, and seems a very long one. Its average trend is N 20° E to N 25° E. For three quarters of a mile south of the quarry it can be followed unbroken, and north of the quarry we have picked it up so repeatedly when crossing its probable location as to convince ourselves that it must be the same dike throughout.

The rock is an ordinary diabase, an augite-feldspar-magnetite combination, lacking olivine. It shows everywhere considerable alteration, the feldspars much kaolinized and the augite largely changed to chlorite. These changes do not seem, however, to have seriously impaired the strength and toughness of the rock and should not, in our opinion, much impair its value as a road rock, for which purpose it has been chiefly used. Because of its width and great length this dike is capable of furnishing a large supply of road material. Where worked it is at low altitude and adjacent to a railroad. Its northern extension is less fortunately situated in these respects, and the same is true of the other dikes of trap in the Precambric. But since the demand for good trap for road-making purposes in New York at the present time is large, and the supply from the dikes in the Adirondack Precambric is the only available source in the State outside of Rockland county, it would seem as if there was opportunity for some development of the industry in the Saratoga region, owing to the unusual length and width of the dikes.

Dolomite. Two quarries have been opened in the upper beds of the Little Falls dolomite, within the limits of the two quadrangles, one on Maple avenue in the northern edge of Saratoga Springs, and the other a mile south of Wilton, Schuylerville quadrangle. In both cases the quarries are in the upper, light colored, coarsely crystalline beds of the formation. In the Maple avenue quarry a thickness of 22 feet of massive beds is exposed with a dip of about 5° to the southeast. The upper bed is full of chert; some of the lower beds are full of drusy cavities lined with dolomite crystals and containing crystals of clear, transparent quartz. A small fault is well shown in the quarry wall which is of interest because it seems very old. The throw is only 2 feet, but a strip of fault breccia about 6 inches wide was produced, which was subsequently solidly welded up by deposit of calcite from circulating waters, so that the rock is as strong and firm as it is anywhere in the quarry. The quarry is worked only intermittently,

Digitized by Google

as demand for stone develops. It is used both for structural purposes and for road metal.

In the quarry near Wilton a twelve-foot thickness of similar beds is shown, also with cherts and drusy cavities containing quartz crystals. This quarry was opened chiefly for road metal purposes, and its product has been much used on the State roads of the vicinity. Some misapprehension as to the true nature of the rock exists in the minds of some people, as we frequently heard it referred to as a trap quarry, perhaps with the idea that any rock used on the roads must of necessity be trap. The material should make an acceptable road metal, though by no means so good as good trap.

Between 3 and 4 miles due west of Saratoga four quarries have been opened in the dolomite, on the west side of the Highland Park fault. The horizon in the formation is somewhat uncertain, but is judged to be near the summit, since Amsterdam limestone is the surface rock a short distance away to the south. The beds are massive for the most part, and consist of alternating courses of dark colored, fine grained stone, and lighter beds of coarser grain. At the time of our visit none of these quarries were being worked and we could obtain but little information regarding them. One of them is quite extensive and the stone is likely used both for structural purposes and for crushed stone.

Limestone. Three of the formations of the district have been quarried for limestone, the Hoyt and Amsterdam limestones of the western basin and the Bald Mountain limestone of the eastern basin.

Two quite large quarries have been worked in the Hoyt limestone, the Railroad quarry and the Hoyt quarry, the former 1 mile north and the latter 3 miles west of Saratoga Springs (plates 5 and 2). Neither has been worked for some years, and the earlier working was to supply lime chiefly for local use. The quarries are thus examples of what has happened on a large scale all over northern New York, the passing of local limekilns and the concentration of the lime industry at a few localities determined by favorable location and quantity and purity of the limestone.

The Amsterdam limestone has been quarried at Rowlands Mill and at Rock City Falls. It was burned for lime to some extent and also used for structural purposes and on the roads. At present it is being extensively quarried at Rock City Falls to furnish crushed stone for concrete.

Digitized by Google

The Bald Mountain limestone has been quarried at Bald mountain and at Middle Falls. On the west face of Bald mountain the steep western limb of the overturned anticline which this limestone forms there, produces a limestone face 100 feet high, which was well adapted to easy and rapid quarrying. The greater part of the material was burned for lime on the spot.

Ruedemann furnishes the following notes on quarries in this limestone noted by him:

The quarry at Middle Falls, which has furnished the fauna, is a small one, showing some 25 feet of heavy bedded limestone quite like that at Bald mountain. The beds are nearly horizontal. The quarry was long ago abandoned, but the material was probably used exclusively for lime.

A half mile west of Middle Falls, on the west bank of Batten kill, at the bend, is a much larger quarry, exposing a thickness of 50 feet of beds, 20 feet of dolomite beneath, and 30 feet of limestone above. The beds are here nearly vertical, with steep dip to west and northeast strike. One and one-fourth miles farther south is another large quarry, and a smaller one yet farther south. The bulk of the material quarried was burned for lime, but the less massive beds were also utilized in structural work. In the report on the first district Mather speaks of the quarries here, which were in active operation at that time.[1]

It is some 40 years since this industry lapsed. There is a large quantity of excellent limestone along this belt, and when the available material at Glens Falls approaches exhaustion, a revival of operations here is not unlikely.

Normanskill grits. There are several abandoned quarries in the grit bands of the Normanskill shales in the vicinity of Quaker Springs. These durable sandstones had a wide use all over the region for structural purposes, but the quarries have been idle for some 20 years.

MINERAL WATERS

The district centering at Saratoga Springs has long been famous for its mineral waters, and especially for its very distinctive, highly carbonated, saline waters. There are in addition numerous sulphur springs in the region, which would probably have a wider repute had the other waters not been also present.

The sulphur waters of the region all rise from the black shales (Canajoharie, Normanskill, Snake Hill), and taste strongly of sulphuretted hydrogen, derived no doubt from the decomposition of

[1] Geol. First Dist., p. 403.

Digitized by Google

the pyrite of these shales. Such waters are of frequent occurrence the world over; nevertheless such a large spring as the "White Sulphur" spring, near the south end of Saratoga lake, would have great notoriety in most districts.

About Saratoga these sulphur waters are plainly not deep-seated waters of any type; they come from no great distance below the surface, and have not reached a depth so great as the base of the shales. So soon as the drill passes through the shales into the dolomite beneath, the carbonated waters are met with, and would surely be mixed with the sulphur waters, had these reached to like depth.

The carbonated waters. There are few problems in geology more difficult than those concerned with the origin of the mineral waters of a specific region. The precise data which can be obtained are always comparatively few, and the problem must be dealt with by indirect methods. In discussing such questions much that is hypothetical creeps into the discussion unawares; and even in regard to certain fundamental matters our information is so far from being precise, that geologists are far from being in agreement concerning them. Certain things in regard to the occurrence and character of the Saratoga carbonated waters have been definitely ascertained and can be definitely set forth; beyond those we enter the realm of uncertainty and can only discuss probabilities or possibilities.

Control of the waters of the Saratoga region has recently passed into the hands of the State of New York, giving an opportunity for definite experimentation on a considerable water supply of unusual character, which has perhaps never before been equalled, and from which definite and certain information of much general interest is sure to come. Prior to this passing of control there had been a period of some 15 years duration of active drilling for mineral water for the purpose of extracting and vending the contained carbonic acid gas. This development took place in the district south and southwest of the village, mostly within a distance of 2 miles from it. A considerable number of wells were drilled, from nearly all of them the waters had to be pumped, and the amount of water so withdrawn annually was very large. Controversial questions arose which resulted in long and complicated litigation, questions such as the source of the waters, quantity of the supply, and underground arrangement of the waters. As an incidental result much detailed information was made public.

Digitized by Google

In a bulletin recently published by the State Museum, Professor Kemp has discussed in exhaustive fashion many phases of "The Mineral Waters of Saratoga."[1] An historical sketch is given, the known geographic extent of the waters stated, and the composition and character of the waters very fully treated, followed by a presentation of his personal views on the origin of the waters. It is no part of our purpose here to present a review or repetition of this most excellent piece of work, which may be obtained by anyone interested in the matter. But one or two phases of the problem do seem to us to merit additional treatment at this time.

Location. The region of abundant carbonated water centers round Saratoga. The original springs, outflowing at the surface, were chiefly in the village and were few in number, and their multiplication and extension has been due to the use of the drill. There has been much drilling in the village and even more to the south, between Saratoga and Ballston.[2]

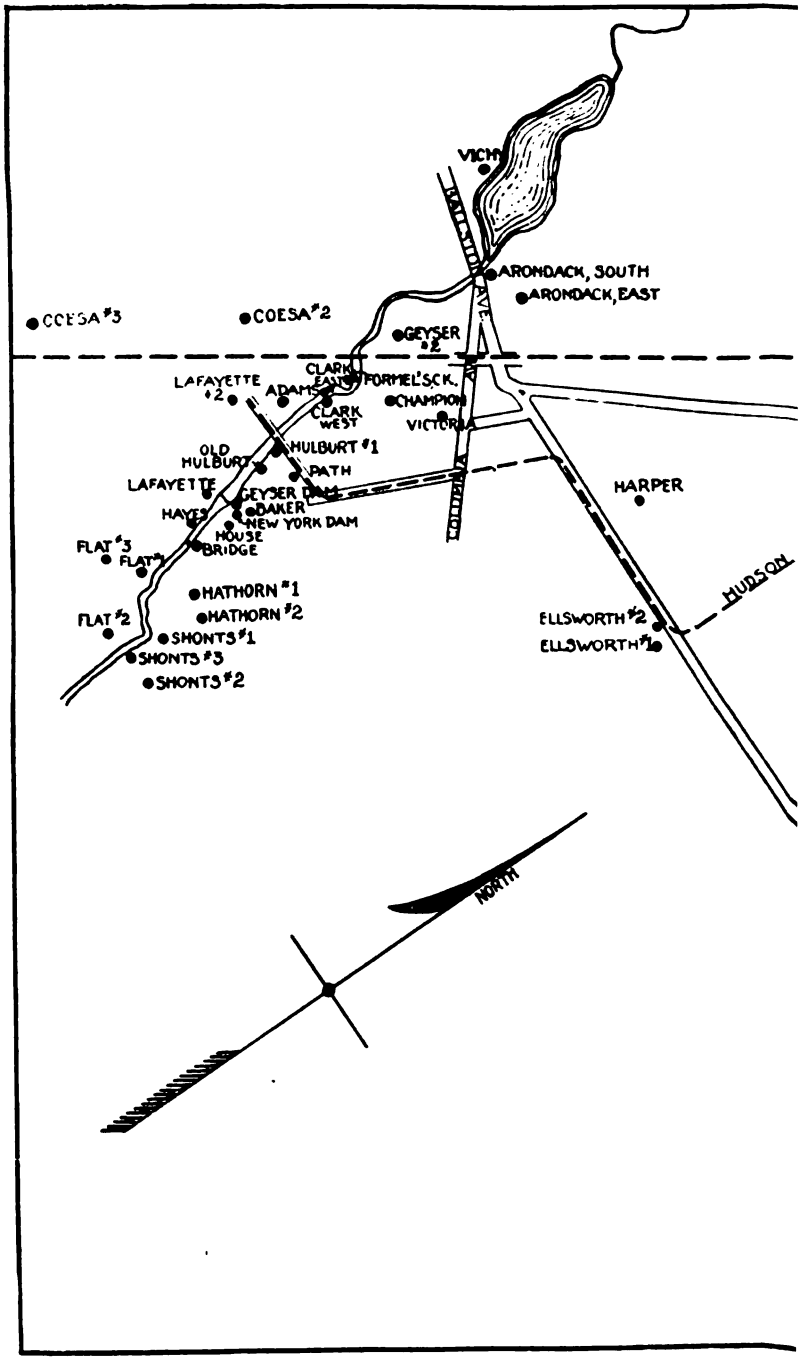
The present springs near or at Saratoga may be conveniently separated into three groups (see accompanying map): (1) the Village group, comprising the line of springs in Saratoga, from the Red spring on the north, to the Congress and Washington on the south; (2) the South Broadway group, the wells of the Natural and Lincoln gas companies, about 1 mile south of the village; (3) the Geysers group, the springs clustered in the vicinity of Coesa creek, about 2 miles southwest of the village. In addition are isolated springs not included in any of the three groups, of which the Gurn spring on the Schuylerville quadrangle, about a mile southeast of Wilton and 6 miles northeast of Saratoga, has the most interest for us.

Geologic occurrence of the waters. The springs in the village all occur on, or in close proximity to, the surface trace of the Saratoga fault. Here are included the original springs, natural outlets of the rock waters. The fault is a trifling one from the standpoint of magnitude, as faults go in the region. Hence the association of the waters with this particular fault must be for a

[1] N. Y. State Mus. Bul. 159.

[2] See Bulletin 159, pages 7–9, for a more complete discussion of the known springs of the general region. One addition should be made to the list, the Vita spring, near the northeast edge of the Schuylerville quadrangle, 10 miles northeast of the Gurn spring, and *east* of the Hudson. The water is quite like that of the Gurn spring, carbonated, and distinctively of the Saratoga type

Digitized by Google



Digitized by Google

Digitized by Google

reason entirely apart from amount of throw. The significant feature of the fault is that shales are the surface rocks on the downthrow side, and are continuously at the surface to the east for many miles.

Away from the fault the drill discloses carbonated water underground only in territory where shales are the surface rocks, territory to the east of the fault. No doubt, in this shale-covered region, the waters have wider distribution than the drill has yet shown. But there is no reason to believe that there will be any disclosure to conflict with the statement that the water is restricted to shale-covered territory, in which the impervious shales prevent its ascension to the surface; that such territory has its western boundary at the Saratoga fault and that the water can and does make its way to the surface along this fault; and that carbonated water has never been found on the west side of this fault and will never be found there.[1] East of the fault the waters are imprisoned under the shales. The Saratoga fault furnishes the line for escape of the water simply because it happens to be the particular fault which terminates the shales on the west.

The rock which acts as the reservoir for storing the water is the Little Falls dolomite. Invariably the drill discovers it in that rock. Occasionally, owing to local conditions, the drill reached water in the Amsterdam limestone, and was not sent down into the Little Falls beneath. But the evidence is clear in such cases that the water had worked its way up into the limestone from the dolomite along some fissure. Only one well in the whole region, the Hathorn bore, has been carried through the dolomite. This well discovered water in the Potsdam underneath. Unfortunately no sample of this water was saved and analyzed, but Mr Hathorn's statement concerning it is that it was water of the general Saratoga type, but very weakly mineralized: hence the well was sealed far above it and only water from the dolomite admitted. In general, the dolomite is not a porous rock. Certain of its beds have a calcite cement and weather porous; but in the drill cores they all seem solid and impervious, and it seems probable that the water supply in the formation is all contained in cracks and fissures, instead of in porous layers.

[1] The Ainsworth well in Saratoga is a possible exception to the above statement since it may be located a few feet west of the fault line. It is, however, practically on the fault line.

Digitized by Google

Northward from Saratoga the broad belt of Hudson Valley shale narrows rather rapidly, and north of Fort Edward but little of it remains. In the Champlain valley but a few patches of shales remain, nothing like a continuous cover. Judging by the Saratoga vicinity, such a cover is necessary both to prevent the free escape of the mineral water and to prevent its admixture with overwhelming quantities of surface water. This fact would seem to account for the nonappearance of these carbonated waters to the north.

The rocks of the general region dip to the south, hence the shale cover thickens southward and the mineral waters, if present, are at a steadily increasing depth below the surface. In the village the driller reported for the Star spring bore, only a short distance east of the fault line, that the bottom of the shale was 100 feet below ground, 38 feet drift, 62 feet shale, then limestone. The Natural Company wells on South Broadway show an average of 140 feet of drift and 50 to 100 feet of shale before reaching limestone. At the Geysers the limestone is still deeper. The Hathorn No. 2 well reported 23 feet of drift and 432 feet of shale above the limestone. At Ballston the shale is 200 feet thicker than this, and the limestone correspondingly deeper. The waters then extend to the south of Saratoga under the shales, but the depth of drilling necessary to reach them steadily increases in that direction, and away from the Saratoga vicinity they do not come to the surface naturally. They likewise extend probably far to the east under the thickening shale cover.

It is by no means unlikely that to the south of Saratoga, the water may extend to the west of the Saratoga fault. As has been previously stated, the course of this particular fault south of Saratoga is conjectural, but on the assumption that it runs down to Ballston, as provisionally mapped, it would be quite possible for the waters to pass beyond it and appear west of it. About Ballston shales are the surface rocks on both sides of the fault, with the Little Falls dolomite below ground on each side under a protecting shale cover. Along the south margin of the Saratoga quadrangle the shales extend entirely across the sheet from east to west, the southerly dip of the rocks giving rise to shales at the surface in each of the successive fault strips. The diagram, figure 16, will explain the assumed course of the underground water, better than can be done verbally.

It is possible to account for the presence of these waters, held imprisoned beneath the shales, in one of two ways. They may

Digitized by Google

be regarded as deep-seated waters which have arisen from depth along the line of the Saratoga fault and spread from the fault plane into the dolomite, in which rock they migrated away from the fault plane and down the dip, to the east and south, thus changing from ascending to descending waters; or they may be regarded as having come from some source to the east and as having used the dolomite as their route toward the west, coming up the dip of the rock as ascending waters, the head supplied from the hills east of the Hudson. Until the Saratoga fault is reached the water is confined to the dolomite by the impervious cover of

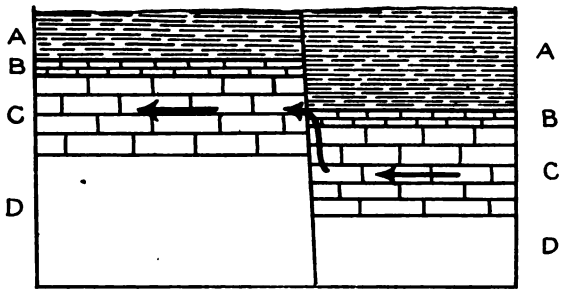


Fig. 16 Diagram of the supposed extension of the Saratoga fault at Ballston. The arrows indicate the course taken by the underground water which comes from the east through the dolomite, rises along the fault fracture to the level of the dolomite on the west (upthrow) side, and passes into that toward the west, the shales preventing it from coming all the way to the surface.

A = Canajoharie shale, B = Amsterdam limestone, C = Little Falls dolomite D = Hoyt, Theresa and Potsdam formations in order.

overlying shale, and at the fault the first opportunity to escape to the surface is given. On this view the waters do not ascend from any great depth along the fault, but merely follow it to the surface from their fissures in the dolomite, below ground on the east side of the fault. In our opinion this latter view represents the true state of the case. Ruedemann was the first to see this clearly, his opinion being based on his structural work in the district of overthrusting east of the Hudson. He has prepared a statement of his views, which appear on page 165 of this bulletin. We are in cordial agreement with his reasoning as there outlined. As previously stated, we think the lack of carbonated waters to the

Digitized by Google

north is readily explained by the lack of the shale cover, so that any possible carbonated water in the region would become diluted and swamped in the general mass of the ground water, which would readily work its way downward into the rocks of the region and drown out the other water. Of his theory in regard to the origin of the carbon dioxid, we shall have more to say shortly.

The shale cover. It is not pretended that the shale cover is absolutely impervious to water; in fact it is known not to be. In places, especially near its thinned, western edge, where less than 100 feet thick, springs of carbonated water broke through it, arising probably along joint cracks. Such cracks are present in all shales, especially near the ground surface, and are present here. A few furnished channels for rising carbonated waters. Enough of them became filled with ground water to transmit the general ground water head to the carbonated rock waters beneath, thus influencing their direction of movement. The matter is perhaps best illustrated by a discussion of the conditions at the South Broadway wells.

Inspection of the topographic map will show that the ground occupied by the Natural and Lincoln companies a mile south of the village along South Broadway, is relatively elevated as compared with the line of occurrence of the springs in the village, or as compared with the springs along Coesa creek. The levels near South Broadway are between 310 and 320 feet, with a summit of something over 320 feet elevation just east of South Broadway. In the village the well heads have a general elevation of 280 feet, which is also the average elevation along Coesa creek. From South Broadway the ground level falls both toward the village and toward Coesa creek (the normal *ground water* level should also fall toward each from a high point on South Broadway), and if this ground water head is transmitted down through the shales along occasional cracks into the waters contained in the dolomite, as seems highly probable, the tendency in these carbonated waters would be also to move away from the South Broadway region toward the village and toward Coesa creek. That is, the water pressures would lend themselves to such a movement of the underground waters and would oppose a contrary movement. If the water head on South Broadway were interfered with and lowered by any cause, this natural flow would be correspondingly weakened and the water levels in the village and along the east side of Coesa creek sympathetically lowered.

Digitized by Google

The generalized section of the rocks above the Little Falls dolomite shown in the Natural Company's wells on South Broadway is as follows:

140 feet Drift	Soil and gray sand	25 feet
	Quicksand	45 feet
	Clay	20 feet
	Sand and gravel	50 feet
118 feet Canajoharie shale	Shale 75 feet	
	Alternating shale and limestone 43 feet	
36 feet Amsterdam limestone		
Little Falls dolomite		

The lowermost drift deposit at the locality is a heavy bed of porous sand and gravel, capped by a twenty-foot thickness of quite impervious Albany clay. When first entered by the drill these lower sands were full of carbonated water, which had got into the sand because of one or more natural springs coming up through the shales and which had been retained there by the cover of impervious clay. There was here a local reservoir of carbonated water at a horizon 150 feet or more above the water in the dolomite. At an early date in the history of the operations of the Natural company this upper reservoir was pumped out and so remained. When full it served to transmit the pressures of the ground waters in the upper sands down to the rock waters beneath; when exhausted of water the hydrostatic column was interrupted and this pressure no longer transmitted, with the result that the normal water head was lost, what amounted to a great cone of depression was produced, and the water levels in the village and on the east side of Coesa creek were affected.

The presence of original carbonated water in this sand we take to demonstrate the presence of outlets for the water in the shales below. The carbonated water came up through the shales and filled the sand reservoir under the clay.

Since pumping ceased all over the district, as it passed under State control, this pumped out reservoir in the sand has been slowly refilling. When such refilling shall be complete and the old ground water head thus restored, we look to see a demonstration of its effect upon the water levels in the lower grounds.

The waters in the dolomite are no doubt following crevices for

Digitized by Google

the most part. There must be a host of these, and the connections between the different water-bearing crevices must vary greatly in character. Some must be very direct and others extremely indirect. So long as they were controlled by the same general hydrostatic head they would be expected to show close sympathy in action, whether the connection were direct or indirect. With the loss of this general head, controlling the water pressures in all the crevices, this close sympathy of action would no longer obtain. Active pumping of a well might quickly and notably affect the water level of a neighboring well, and not at all affect another well equally near to the first but in a different direction from it. In the first case the underground connections would be fairly direct; in the second case very indirect; but under the circumstances the conclusion that there was no underground connection whatever between the two wells, might not be justified at all.

Have the waters a common source? The carbonated waters of the Saratoga region are peculiar. The abundance of carbon dioxid, of sodium chlorid, and of calcium, magnesium and sodium bicarbonates, and the almost entire lack of sulphates, gives them a character which is possessed by few other natural waters the world over. Taken together with their restricted distribution, this leads irresistibly to the conclusion that they have a common source. They distinctly impress us as mixed waters, waters which have not obtained all their dissolved mineral matter at the same time and place and which, probably in the latter stages of their underground journey, have become diluted in varying degree with fresh, surface waters. The varying degree of mineralization of the waters of the different springs, when compared with one another, is most simply and naturally accounted for in this way. The statement which has been made in regard to some of the pumped wells, that unusually prolonged and vigorous pumping of a well results in bringing to the surface brine of increased strength, seems to us to point to the same thing. Under these circumstances less dilution with fresher surface waters takes place than is normal for the particular well.

By a common source we mean that the original mineralization of the waters takes place in a specific underground area of unknown extent, owing to specific chemical reactions of unknown nature, and that from this area the waters follow a definite route to the surface, no doubt undergoing further mineralization on their way. Our conception of the route is that from a deep-seated

Digitized by Google

source to the east the waters follow the upward inclines of the thrust planes and of the beds of dolomite, which eventually lead them to the surface in the Saratoga region; that in the dolomite the waters make their way along a multitude of fissures or cracks in the rocks, constituting a great network of channels which are all connected when considered at large, but which locally may, or may not, be closely connected.

Summary. We hold it to be demonstrated that the Saratoga carbonated waters, as they exist underground, are confined to the district which has a shale cover, underneath which they are held imprisoned in the Little Falls dolomite; and that the water originally found escape, to a limited amount, along the Saratoga fault and through the shales near their thinned western edge. Certain of these outlets were known, but there were also others in unknown number hidden under cover of overlying glacial drift. We hold it to be in the highest degree probable that the waters are mixed waters, that they have in part a deep-seated source, and that they come from the east, following up the thrust planes and up the dip of the dolomite beds, utilizing fractures in the dolomite as their channels. When their path is blocked by a normal fault, they utilize it to rise to the level of the dolomite on the upthrow or west side, and then reenter the dolomite. When the particular fault which terminates the shales on the west is reached, the waters rise to the surface along it wherever the ground levels permit. The village springs and the Gurn spring are located on such a fault. The Vita spring and the springs along Coesa creek rise through the shales, quite possibly along a fault, though the fault has not been demonstrated in either case.

When we pass from these matters to those concerned with the amount and permanence of the water supply, and to the question of the origin of the waters, we are dealing with questions of quite another sort, questions regarding which wide differences of opinion prevail, and concerning which we can obtain little or no direct information.

The water supply. Below ground the manufacture of this mineral water either has, or has not, ceased. It is still being manufactured, or it is not. If not, then we are dealing with a stored water supply of definite amount, which can be pumped out and exhausted, just as underground stocks of petroleum and of natural gas become exhausted. It seems to us unlikely that this is a case of the kind. Springs have been flowing at Saratoga ever since the region became known, and for an unknown length of

Digitized by Google

time prior to that, no doubt a very long time. There is much natural escape and there are too many outlets to allow us to believe that the original supply, however large, could have withstood such a steady drain on its resources. We are rather forced to the belief that we are dealing with a great, underground water circulation in natural equilibrium, inflow and outflow being equal, and that the rate of natural outflow measures for us the rate of manufacture and of inflow. If this be true, there is not the same danger of exhaustion of the supply that there would be in the other case. But this is a very different thing from saying that the supply is unlimited and can be drawn on indefinitely at a rate much in excess of the normal circulation.

The origin of the water. Any discussion of this problem must of necessity be almost wholly theoretical. Our lack of definite knowledge of too many of the factors is too great to permit it to be otherwise. We refer to it at all here only because Professor Kemp has exhaustively discussed the problem in Bulletin 159, and because we wish briefly to consider one or two points made in that discussion. A brief synopsis of his argument must precede.

Kemp gives a very exhaustive discussion of the composition of the Saratoga waters. Omitting minor constituents, they are characterized by high content of chlorids and bicarbonates of sodium, calcium and magnesium, high content of uncombined carbon dioxid, and extremely small content of sulphates. He distinguishes three divisions of underground water from the standpoint of origin, meteoric waters derived from the rainfall, magmatic waters derived from cooling igneous rocks, and connate waters, generally marine waters buried in the rocks at the time of deposit and retained in them. Then by a process of elimination he rules out connate waters as a possible contributing source for the Saratoga waters, in whole or part, because they lack sulphates in solution. He dismisses meteoric waters as a possible source of the carbon dioxid and the chlorids, because we know of no chemical method by which they might be produced in such waters in the Saratoga region; and he finally concludes that these constituents are therefore likely of magmatic origin. His summing up is as follows:

> The explanation which appeals most strongly to the writer is that the carbonic acid gas, the chlorids, bromids, iodids, fluorids and sodium carbonate are deep-seated. The sodium carbonate might in part or in whole be dissolved from the feldspars in the old crystalline rocks. The carbonated waters take on calcium and magnesium carbonates from the limestones encountered in their upward journey, more especially from the Little Falls dolomite.

Digitized by Google

Our purpose here is not at all to express disagreement with these views of Kemp. We are not sure that we do disagree with them. Kemp has made an important contribution to the geology of the mineral waters of the region, by elaborating a definite theory concerning their origin. We simply wish to emphasize the difficulty and complexity of the subject, and our lack of definite data regarding it, and to suggest alternative views in one or two respects.

We feel quite confident, in the first place, that the volcanic knob at Northumberland is no evidence whatever of underground igneous action, in the general region, of sufficient recency to have any bearing on the question of the existence of present-day juvenile waters underground. It does not show that such water does not exist. But we think that the evidence for the presence of such water is wholly independent of the presence of the plug, and is neither strengthened nor weakened by it.

We quite agree that the carbon dioxid and the chlorids have a deep-seated source, but we think Ruedemann's suggestion as to the possibility of the carbon dioxid arising from deep-seated metamorphism of the rocks is quite worthy of consideration as an alternative hypothesis to the juvenile one.

The tangential pressures which gave rise to the overthrusts may have operated up to very recent times and may still be in operation. They must aid in metamorphosing deeply buried sediments. In such sediments there is generally much lime, partly as beds of pure limestone, partly in impure limestones, calcareous shales and calcareous sandstones. In regions of metamorphosed sediments it is the common experience to find the limestone formations converted to marble and retaining all their original carbon dioxid. The impure limestones and the calcareous shales, on the contrary, recrystallize to schists containing little or no calcium carbonate. but much calcium silicate in such minerals as pyroxenes, amphiboles, garnets etc., and we must assume that the calcium has been recombined and carbon dioxid set free. Kemp lists this process as one of the methods of the manufacture of uncombined carbon dioxid below ground, and states its possible applicability to the Saratoga region, but dismisses it as, to his mind, less likely than an igneous source. But when combined with Ruedemann's theory of the eastern source of the water it seems to us to take on greater probability and to be worth considering as a source of the gas.

Nor do we feel at all certain that connate waters are to be entirely ruled out of the question. The lack of sulphates in the

Digitized by Google

Saratoga waters is a very real difficulty. But the possibility of the sulphates having been precipitated somewhere along the long route of water ascent, may be suggested as an alternative view. Such a reaction as that investigated by Hilgard some years ago, a solution of sodium sulphate in presence of free carbonic acid dissolving calcium carbonate, with formation of sodium carbonate and precipitation of calcium sulphate (gypsum), suggests what may conceivably have happened.[1] That connate waters of marine derivation must have originally contained sulphates does not seem to us open to question; but it does not necessarily follow that, on admixture with other waters, the sulphates should persist in solution. We do not urge this as a probability but merely as a possibility. It does not seem to us proven that the Saratoga waters may not receive a contribution from a connate source.

These observations are in no sense a criticism of Kemp's theory, but merely intended to emphasize the difficulty and complexity of the subject. The two main difficulties in the way of unqualified acceptance of the juvenile origin of the Saratoga waters are that they are not thermal waters, and that we have no direct evidence of igneous action of any recency in the vicinity, or anywhere else in the eastern United States. It is the latter fact particularly that makes us cautious and causes us to reserve judgment and leads to the suggestion of other possibilities. The theory is not condemned by us; we regard it as very likely true. But we do not as yet see our way to its unreserved acceptance.

A paragraph at the close of Dr F. W. Clarke's discussion of Mineral Wells and Springs so well expresses our state of mind that we conclude by quoting it.[2]

And yet, notwithstanding all that has been written on the subject, the controversy over the genesis of hot springs is not closed. What is the origin of the carbon dioxid with which so many mineral waters are heavily charged? In some instances, doubtless, it is derived from the decomposition of limestones, but in others this explanation can not suffice. Here and there it may be, to use Suess's expression, "juvenile," and evidence of the deep-seated origin of a spring. Again, whence comes the sodium chlorid of waters that flow from sources where it could not have been previously laid down? These questions, and others like them, still await satisfactory answers.

[1] Am. Jour. Sci., 4th ser., 1896. 2:100.

[2] U. S. Geol. Surv., Bul. 491, p. 203.

Digitized by Google

RELATIONS OF THE SARATOGA MINERAL SPRINGS TO THE STRUCTURE OF THE SHALE BELT OF THE UPPER HUDSON VALLEY.

BY R. RUEDEMANN

The study of the shale belt of the Saratoga and Schuylerville quadrangles by the writer has brought out certain structural features which appear to explain the accumulation of the mineral waters in the Saratoga region.

The salient facts in the distribution of the mineral water for the discussion here presented are : (1) the mineral springs are distributed in a belt extending in a northeast-southwest direction, from the Gurn spring to Ballston Spa and farther south (Albany?) ; (2) the waters come up in connection with or near a fault line, extending in this direction; (3) the water does not occur west of this fault line, but is found far to the east of it (Quaker spring and Vita spring) ; (4) it is stored in a series of limestone, dolomite and sandstone formations underlying a shale formaton.

The investigations of the writer have now shown that the shales forming the surface rocks east from the springs fault belong to two entirely different series or sets of formations which were deposited in two separate basins.

The western set begins on top with the Canajoharie shale. This is underlain by the Glens Falls and Amsterdam limestones, the Hoyt limestone, Little Falls dolomite and Potsdam sandstone, the latter resting on Precambric rocks, mostly gneiss.

This western series, which sinks in one or two step faults from the Precambric area of the Adirondacks to the level of the Saratoga plain, is but little disturbed and the beds are but little tilted and not folded. It continues eastward to an unknown extent, which, however, must be considerable since only the western edge of the old basin is now exposed on the surface. Undoubtedly it extends as far as the eastern hill region, as indicated in sections.

Only 3 miles east of Saratoga an entirely different set of formations begins to appear on the surface. In this set most formations are represented by shale, namely, the Trenton by the Snake Hill shale, the Chazy by Normanskill shale, the Beekmantown by Bald Mountain limestone (thin), Deep Kill shales (thick) and Schaghticoke shale, and the Cambric by the Georgian shales, slates, limestones and quartzites. This set of formations, as their lithologic character and faunas show, has been formed in another more

Digitized by Google

easterly basin. The diastrophic movements, which raised the Green and Taconic mountains, have not only intensely crumpled and folded this entire mass, but also shoved it a great distance westward until it has overridden the western set of formations to within a few miles of Saratoga.

The combined effect of this great overthrusting of the eastern shale masses on the western set of formations has evidently been that the limestones of the latter have been buried under an immense mass of shales. At Mechanicville, for instance, only a few miles from the western edge of this shale mass, a well was sunk 1400 feet through these shales without reaching their bottom. Further, this mass undoubtedly forced the western set of rocks downward, a process which was helped by step faults such as occur at Saratoga farther west.

We thus get a set of limestone and sandstone formations that descends gradually eastward to greater and greater depths, becoming all the time buried under greater masses of impervious shales. The mineral waters, which for good reasons are considered as coming from the east, find thus a channel in the jointed and broken limestones and porous sandstones, gradually rising westward until they strike the Precambric block at Saratoga, where they rise along the Spring fault and through the relatively thin shale cover to the surface from the storage basin that is formed in the fault block upon which the eastern part of Saratoga Springs stands. This underground course of the water is indicated in the sections on plate of sections by the blue line.

The pressure necessary to bring the waters on the long journey from the east through this underground channel is probably supplied through the head obtained from the mountain regions in the east.

It is not intended to explain the origin of the carbonated mineral waters by the structure of this basin, although the possibility may be suggested that the limestones may in their eastward descent reach such depths that they may become subject to metamorphism through which the carbonic acid and some of the salts become dissociated. At any rate, the known regional metamorphism of the rocks of the eastern trough in the Taconic-Green mountain regions is a fact worth remembering in this connection, and the

Digitized by Google

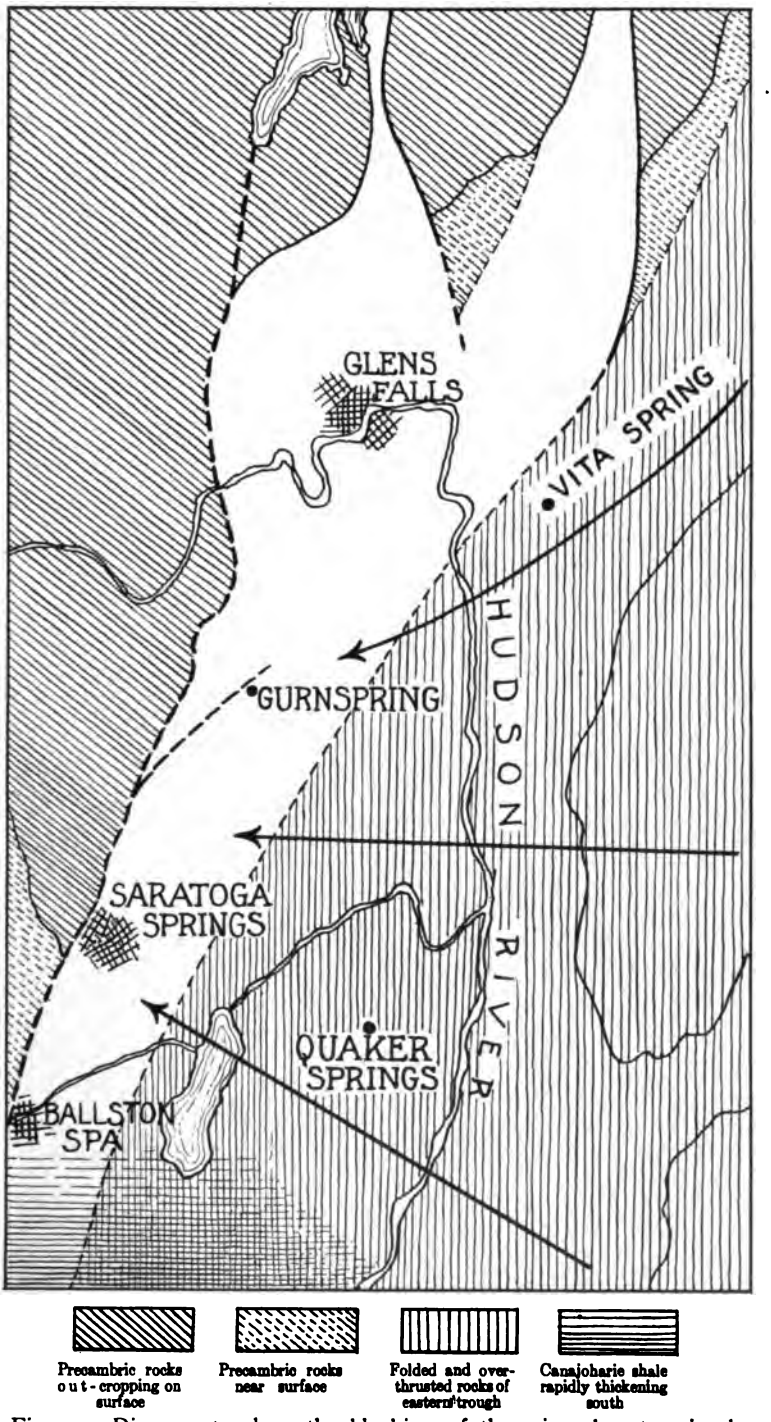


Fig. 17 Diagram to show the blocking of the mineral waters in the Saratoga region by fault blocks of Precambric rocks in the north and west and the thickening cover of shales at the east and south.

Digitized by Google

Digitized by Google

possibility of the continuation to the present time of these processes that metamorphose the shales, limestone and sandstones into schists and gneisses in the depths of the mountains is not at all disproved. At the same time it is also possible that these same limestones and sandstones come within the influence of deep-seated, still heated igneous rocks, thence deriving their carbonic acid, and at the same time that they gather "connate" waters (original sea water deposited with the rocks) from a large area and held in the depths, to which they descend, through the thick covering masses of shales.

One naturally asks here why these waters only come up in the Gurnspring-Saratoga-Ballston belt, a stretch altogether not more that about 12 miles long. The geologic structure of the region is responsible for this phenomenon (see diagram, text fig. 17).

South of Ballston the shales again thicken rapidly on account of the southward dip of the beds, until at Schenectady they reach no doubt more than 3000 feet in thickness, thus shutting the waters off from the surface to the south of the Saratoga mineral springs region. Northward of this region the structural relations are not yet well understood and the reasons for the absence of the springs not apparent. At Glens Falls the "Trenton" and Black River limestones come again to the surface but without bringing any mineral water. This outcrop is apparently the southern spur of a fault block. It probably fails to intercept the mineral waters coming from the east because it lies west of another large fault, which is indicated by the Fort Ann spur of Precambric rocks and which extends close to or into the crumpled shales of the eastern basin, thus shutting off the mineral waters from access to more western regions or to the surface altogether. We have seen before that the Precambric rocks west of the Spring fault form a barrier for the waters in that direction and that the thick masses of shales east of the area serve there as a competent cover. The Spring belt is thus shut in on all four sides by either thick masses of shales (east and south) or barriers of Precambric rocks (west and north) and in the belt itself the waters are brought nearest to the surface in following the routes of least resistance.

Digitized by Google

CONTROL OF DEVELOPMENT AND HISTORY OF SARATOGA REGION BY THE GEOLOGY

BY R. RUEDEMANN

Saratoga and Schuylerville (the original Saratoga) quadrangles are historic ground. The battles of Bemis Heights and Saratoga (present Schuylerville) which have been cited among the fifteen decisive battles in the history of the world, were fought on this ground, and these, more than any other events of the Revolutionary War, the people of the United States have to thank for their freedom.

Any one who studies this region with an interest both for its fascinating history and its geology, can not fail to be impressed by the close relationship between the course of the historic events and the geology of the region. In view of the especial interest attaching to anything connected with the history of Saratoga, it may therefore be well briefly to point out the influence of the geology upon (1) the development of the region, and (2) the course of the struggle between the American and British armies.

The Hudson river formed the natural highway through this country not only for the Indians but also throughout colonial history. The early Dutch settlers followed this stream into the northern woods and first settled the fertile bottom lands and then the edge of the rich land on top of the clay banks laid down in Lake Albany. When Burgoyne pressed into the country he found only this thin first line of settlements, while back of the river on both sides there extended the primeval forests. Here the Dutch reached the northern limit of their settlements and gave names to the Moses kill, Snook kill, Batten kill and Fish kill. Later, New England pioneers came from the east through the mountain passes provided by the Batten kill.

While the fertile clay plains and bottom lands along the river attracted the first farming population, another geologic influence created a second center of settlement in the western, less fertile, sand region of these quadrangles. This was the mineral springs that issued at the foot of the fault scarp at Saratoga and which were already highly valued by the Indians for their healing qualities. Because of them Saratoga Springs, in the middle of the former century, became the foremost summer resort of the continent and the largest town on the two quadrangles, and on their account the railroad trunk line from the Hudson river through

Digitized by Google

the Champlain valley to the St Lawrence, the Delaware & Hudson Railroad, does not follow the Hudson river to Fort Edward as one would expect, but leaves it at Mechanicville to swing far to the west. Thus again the influence of the faults which bring up the mineral waters of Saratoga is strongly felt in the distribution of the population of the quadrangles and the direction of the principal railroad.

A third geologic agent which controls the distribution of the settlements and which is constantly growing in importance is the presence of rapids and waterfalls in the rivers and brooks. These are due to two causes in the region, first, the greater erosive power of the Hudson river over that of its tributaries on both sides, whereby the latter flow in "hanging valleys" and are forced to reach the level of the river along a series of falls and rapids in their lowest course; and, second, the rejuvenation of the rivers by the glacial period, in consequence of which in their new, immature courses they frequently meet ridges of harder rock protruding into the glacial deposits from the irregular preglacial surface, and in such places are dammed up and form falls or rapids. Thus Schuylerville and Victory Mills grew up where Fish creek falls into the deeper Hudson valley; Ballston Spa where the Kayaderosseras creek falls into the old preglacial fault depression of the Saratoga fault; Thomson and Fort Miller where the Hudson river plunges over ridges of shales, chert and grit that block its way. Likewise Gansevoort is located where the Snook kill strikes a line of anticlinal ridges and overthrusts in the Canajoharie shale and supplies water power by a waterfall, and Clark Mills where the Batten kill crosses a ridge of harder Normanskill rocks; Middle Falls where it is held up and falls over the Bald Mountain limestone, and Greenwich where the olive grits of the Georgian formations force the Batten kill to form rapids and supply water power. It is thus seen that every village in the shale belt is located where water power is produced by the geologic structure of the region.

Equally interesting with the control of the settling of this region by its geology is that of the events of the battles of Saratoga by the same agency.

Burgoyne had two routes to reach the Hudson river and thereby Albany, his objective point; namely, first, the deep depression extending from Whitehall to Fort Edward and caused largely by the downfaulting of the Ordovicic rocks at the eastern base of the Adirondacks and, second, the fault basin of Lake George. He

Digitized by Google

selected the former and entered the swamp region of Wood creek, following this creek with its immature swampy drainage up toward the Hudson. Here it was extremely easy to impede his progress by cutting trees and throwing them across the road, an opportunity of which the Americans made the fullest use. Burgoyne wasted months of valuable time and his best energy and provisions in these swamps of glacial origin. When he finally reached the Hudson he followed it on the east side until he found the place where at Thomson the river falls over a ridge of harder Normanskill shale below which a bridge could be easily built. After crossing he was again forced to the river bank by the only road available, while deep ravines cut into the thick clays of Lake Albany made excellent opportunity for a defensive position for the American army. Such a position was selected at Bemis Heights.

On the other side of the river towers Willard mountain, an erosion remnant due to the hardness of the grits and cherts of Normanskill age that compose the syncline. From this bold mountain every movement of the British army could be easily seen by the patriot Willard and signalled to General Gates.

After his defeat, Burgoyne retreated leisurely and sullenly up the river. Hessian officers advised him to leave his cannon and baggage behind and save the army by a forced retreat by way of Lake George, but the obstinate though brave general decided to return by the crossing at Thomson, allowing by his slow and undecided action the Americans to overtake him and, in using the peculiarly favorable topography of the locality, which is due to its remarkable geology, to prepare a trap for him. The most important feature of this topography is that just above the Thomson crossing a volcanic rock, known as the Northumberland volcanic plug, juts out prominently toward the river, so that it has complete command of the crossing and at the same time prevents an army from passing under it at the west bank of the river. This important strategic point was occupied by Colonel Stark. It, and Fellows's batteries which could be advantageously placed on the bluffs of Albany clay on the opposite bank of the river, were, with Morgan's sharpshooters in the woods to the west of the army, the principal means of forcing Burgoyne to surrender. Thus we see that the peculiar combination of a ford over a shale ridge, a volcanic rock close by and bluffs of clay aided greatly in bringing about the decisive victory of Saratoga.

Digitized by Google

INDEX

Acrotreta emmonsi, 72
sagittalis taconica, 72
Adams, F. D., cited, 24
Adirondack highland, 8–10
Agraulos, 37, 38
saratogensis, 42
Albany, molding sand, 148
Albany county, Canajoharie shale, 100
Albany, Lake, 146, 147
Amphibolite, 18, 19, 20, 21
Amsterdam limestone, 31, 45–47, 60, 61, 62, 63, 138, 139, 149, 151, 165
Analyses, diabases, 30; Laurentian granite, 24
Andesine, 18, 28
Anorthosite, 16, 26
Apatite, 21, 23, 28
Archinacella orbiculata, 97, 99
Arthroclema pulchellum, 47
Asaphus platycephalus, 76
Ashburner, C. A., mentioned, 90
Atops trilineatus, 66, 108
Augite, 29

Bald Mountain, 7, 14, 66, 72, 73, 77, 108, 114
Bald Mountain limestone, 66, 75–80, 106, 108, 110, 113, 141, 149, 151, 165; first use of term, 78
Ballston Springs, 101, 105
Bassler, R. S., cited, 83
Bathyurus spiniger, 47
Batten kill, 13, 14, 103, 111, 112
Beekmantown group, 138
Beekmantown limestone, 42, 66, 108, 165
Biotite, 18, 21, 23, 28
Black lake, 10
Black mica, 18, 21
Black patch grit, 67, 69
Black River history, 138–42
Black River limestone, 31
Bomoseen grit, 66, 69, 71
Botsfordia caelata, 72
Brainerd, E., cited, 42
Broadalbin quadrangle, 5
Bythocypris cylindrica, 80

Calymmene senaria, 76, 97
Cambric black shale, 67, 69
Cambric history, 32–45, 136–37
Cambric roofing slates, 67, 69
Cameroceras brainerdi, 77
Canajoharie shale, 31, 47, 48–51, 59, 60, 61, 100, 101, 102, 105, 139, 165
Carabocrinus *cf.* radiatus, 96
Carbonated waters, 153–54
Cenozoic history, 145–46
Ceratiocaris, 67
Ceraurus *cf.* pleurexanthemus, 80
Chadwick, G. H., cited, 115
Chazy basin, 31; deposits, 136–37
Chazy limestone, 66, 138, 165
Chrysoberyl, 23
Clark, P. Edwin, cited, 112
Clark Mills, 103
Clarke, F. W., cited, 164
Clarke, J. M., cited, 38, 42
Clathrospira subconica, 97
Clidophorus, 99
foerstei, 96
ventricosus, 96
Climacograptus bicornis, 86, 92, 93
modestus, 86, 92
parvus, 91, 92, 93
putillus *var.* eximius, 93
scharenbergi, 91
spiniferus, 50, 97, 99
Clinton county, 29, 34
Clitambonites americanus, 96
Columbia county, table showing the Lower Cambric series, 68
Columnaria halli, 47
Conocoryphe *sp.*, 67

Digitized by Google

Corinth, 12, 34, 59
Corynoides *sp.*, 96
  calicularis, 50, 51, 98
  gracilis, 91, 92, 98, 99
Cremacrinus *sp.*, 96
Cryptograptus tricornis, 92
Cryptozoon, 39, 44
  sp., 77
  proliferum, 42, 45
Crystalline rocks, 7, 8
Ctenobolbina subrotunda, 97
Ctenodonta, 99
  declivis, 96
  levata, 96
  prosseri, 96
  radiata, 96
  recta, 96
  subcuneata, 96
Cumings, E. R., cited, 54, 56
Cuneamya acuitrons, 97
Cushing, H. P., Location and character, 6-7; General topography, 8-15; General geology, 15-16; Paleozoic rocks of the western trough, 30-32; Structural geology of the western basin, 53-65; The Northumberland volcanic plug, 115-35; Economic geology, 148-52; cited, 21, 31, 38, 42, 107, 134; mentioned, 73
——— Ruedemann, Rudolf, Historical geology, 135–48
Cyclonema cushingi, 97
  montrealense, 97
Cyclora *cf.* minuta, 97
Cyrtoceras confertissimum, 77

Dale, T. Nelson, cited, 11, 66, 67, 70–71, 76, 79, 85, 86, 87, 89, 90, 103, 109, 110, 112, 113
Dalmanella rogata, 47
  testudinaria, 76, 96, 98, 99
Darton, N. H., cited, 53, 59, 60
Davis, W. M., cited, 118
Deep kill, 111
Deep Kill graptolite fauna, 112
Deep Kill shale, 66, 75, 141, 142, 165
Descriptive geology, by H. P. Cushing, 16–30
Diabase, 17, 21, 28–30; analyses, 30
Diamond Rock quartzite, 70
Dicellocephalus hartti, 42
  tribulis, 42
Dicellograptus sextans, 92
Dicranograptus contortus, 93
  nicholsoni, 50, 96, 97, 99
  ramosus, 91, 92
Dictyonema flabelliforme, 73, 74
Didymograptus sagittarius, 92
  sagitticaulis, 92
  subtenuis, 91, 92
Dikes, 21, 23, 27, 28–30
Dinorthis pectinella, 47
Diorite, 28
Diplograptus *cf.* acutus, 91
  amplexicaulis, 50, 88, 93, 97, 98, 99
    var. pertenuis, 97, 98, 99
  (Mesograptus) mohawkensis, 50
  (Mesograptus) putillus, 50, 96, 97, 98
Dolomite, 150–51
Drainage, 12–13
Drumlins, 14

East Galway, 46, 56, 59
Eastern trough, Paleozoic rocks, 66–99
Eccyliopterus planibasalis, 77
  planidorsalis, 77
Economic geology, by H. P. Cushing, 148–52
Eddy Hill grit, 66, 69
Edrioaster saratogensis, 96
Elizabethtown quadrangle, 28
Elliptocephala asaphoides, 66, 72, 108
Emerson, B. K., cited, 118
Emmons, Ebenezer, cited, 66, 76, 79, 108
Empire Graphite Co., 148
Eoharpes ottawensis, 97
Eopolychaetus albaniensis, 50
Eridotrypa minor, 47

Digitized by Google

Faults, 10, 16, 30, 103; general remarks on, 63–65; of Mohawk valley, 53–57; of Saratoga and Broadalbin quadrangles, diagram, 55
Feldspar, 18, 19, 20, 21, 23, 25, 28, 29
Feldspar-quartz gneisses, 18
Ferruginous quartzite and sandstone, 67, 70
Fish creek, 12, 13, 104
Fisher, W. L., cited, 54
Folded area, 102–7
Foliation, 30
Ford, S. W., investigations by, 66
Fort Cassin beds, 78
Fort Edward, 12, 101, 102
Fort Miller, 94
Frankfort formation, 52, 53

Gabbros, 17, 21, 26
Gansevoort, 101
Garnets, 18, 21, 23, 25, 28
Geology, general, by H. P. Cushing, 15-16; descriptive by H. P. Cushing, 16–30; control of development and history of Saratoga region by, 168
Georgian overthrust blanket, 107–8
Georgian rocks, 49, 66, 108, 111, 165
Girvanella *sp.*, 77
Glacial period, 13, 146–48
Glens Falls limestone, 31, 47-48, 165
Glossograptus, 86
ciliatus, 93
quadrimucronatus *mut.* cornutus, 50, 51
mut. pertenuis, 97
Glowegee, 101
Glowegee creek, 34
Glyptocrinus, 96
cf. decadactylus, 98
Gneiss, 18, 24
Grabau, A. W., cited, 75
Graben, 16
Granite, 16, 17, 21-22, 25, 26, 28, 149
Grants hollow, 112
Graphite, 18, 20, 148–49
Graptospongia pusilla, 92
Greenfield township, 34, 35
Greenfield limestone, 38
Greenwich, 110
Greenwich plateau, 11; structure, 107–15
Grenville series, 16, 17-20, 27, 135, 148
Gurnspring fault, 60

Hall, James, cited, 38, 39
Hathorn spring record, 63
Heterocrinus gracilis, 96
High Rock spring, 62
Hill, B. F., cited, 21
Historical geology, by Cushing and Ruedemann, 135–48
Hoffmans Ferry, 10
Hoffmans Ferry fault, 54, 56, 58
Hoosic river, 111
Hormotoma (Murchisonia) cassina, 77
Hornblende, 18, 28
Hoyt limestone, 31, 32, 38–42, 60, 61, 137, 141, 151, 165
Hudson Falls, 102
Hudson grit, 86
"Hudson River" formation, 52, 90
Hudson Valley lowland, 10-12
Hyolithes communis, 67
Hyolithellus communis, 72
micans, 67, 72
rugosa, 72

Igneous rocks, Precambric, 21–30
Indian Ladder beds, 53, 142
Iphidea pannula, 67
Isochilina armata *var.* pygmaea, 80

Joints, 65

Kayaderosseras creek, 12, 13, 48, 49, 50, 101
Kemp, J. F., acknowledgments to, 6; cited, 21, 28, 30, 154, 162
Kendrick's hill, 11
Kings Station, 20, 60

Labradorite, 29
Lake Albany, 147

Digitized by Google

Lake Vermont, 147
Lasiograptus bimucronatus, 93
eucharis, 50, 51, 98, 99
Laurentian granite, 16, 17, 21–22, 25, 149; analyses, 24
Leperditia *n. sp.*, 47
dermatoidea, 67
Lepidocoleus jamesi, 97
Leptobolus *sp.*, 93, 97
insignis, 50, 98
walcotti, 92
Leptograptus *sp.*, 91
flaccidus *mut.* trentonensis, 92
Levis trough, 114
Limestones, 7, 17, 19, 20, 151–52
Lingula, 67
sp., 80
Lingulella (Lingulepis) acuminata, 35, 38, 39, 42, 44
coelata, 67
granvillensis, 67, 72
Lingulepis acuminata, 34, 38, 42
Linnarsonia sagittalis *var.* taconica, 67
Liospira *sp.*, 77
Little Falls, 10
Little Falls dolomite, 31, 32, 39, 40, 42–45, 58, 59, 60, 61, 62, 137, 139, 141, 149, 150, 155, 161, 165
Lonchocephalus calciferus, 42
Lonely lake, 15
Long Lake quadrangle, 28
Lorraine formation, 52
Lowville limestone, 138, 139
Lyrodesma schucherti, 97

McGregor fault, 54, 60
Maclurea, 76
Magnetite, 21, 28, 29
Martinsburg shale, 51
Matherella saratogensis, 42
Matthewia variabilis, 42
Mechanicsville, 91
Merrill, F. J. H., cited, 76
Mesograptus mohawkensis, *see* Diplograptus (Mesograptus) mohawkensis
Mesograptus putillus, *see* Diplograptus (Mesograptus) putillus
Mesozoic history, 143–45
Mettawee slate, 69
Mica, 18, 20, 21, 23, 27
Microcline, 23
Microdiscus connexus, 67
lobatus, 67
speciosus, 67
Microperthite, 23, 24
Middle Falls, 75, 77, 78, 152
Miller, W. J., acknowledgments to, 6; part of Saratoga quadrangle mapped by, 5; report on Broadalbin quadrangle, 5; cited, 27, 31, 34, 35, 39, 47, 53, 54, 56
Mineral springs, relations to shale belt, 165–67
Mineral waters, 152–64
Mohawk lowland, 10, 114
Mohawk region, faults, 54–57
Molding sand, 148
Moordener kill, 82
Moraines, 13–14
Moreau pond, 15
Morley, E. W., cited, 24
Moses kill, 111
Mt McGregor, 26, 101
Murchisonia *sp.*, 42
cassina, *see* Hormotoma (Murchisonia) cassina

Nassau beds, 70
Normanskill fauna, 91
Normanskill grit, 86–91, 152
Normanskill shale, 49, 66, 73, 84–93, 102, 111, 113, 142, 165
North Milton, 46
Northumberland volcanic plug, 115–35, 107, 149, 163

Obolella, 67
crassa, 72
Obolus prindlei, 72
Olenellus, 67
sp., 72
Oligoclase, 18, 23, 24
Olive grit, 67, 69, 71
Olivine, 29
Oolite, 39
Ophileta, 78

Digitized by Google

Ordovicic history, 137–38
Orthis salemensis, 67
Orthoceras arcuolineatum, 50
hudsonicum, 50
Orthodesma subcarinatum, 96
Oxydiscus *sp.*, 77
Ozarkic system, 32

Pachydictya acuta *var.*, 47
Paleozoic history, 136; later, 142-43
Paleozoic rocks of the eastern trough, by R. Ruedemann, 66–99
Paleozoic rocks of the western trough, by H. P. Cushing, 30–32
Paleschara ulrichi, 96
Parastrophia hemiplicata, 96
Pegmatite, 18, 22–23, 25
Pelagiella hoyti, 42
minutissima, 42
Peneplain, 8
Phlogopite, 20
Phyllodictya varia, 47
Plaesiomys retrorsa, 96
Plagioclase, 18
Platyceras primaevum, 72
Plectambonites pisum, 80, 81, 82
sericeus, 97, 98, 99
typus, 96
Plectorthis *cf.* whitfieldi, 96
Pleistocene history, 146–48
Polytoechia apicalis, 77
Pontobdellopsis, 98
cometa, 50, 98
Porter Corners, 20, 44; graphite, 148
Potsdam sandstone, 31, 32, 34–35, 58, 59, 60, 63, 136–37, 141, 165
Precambric rocks, 16–30
Proëtus undulostriatus, 97, 98
Prosser, C. S., cited, 38, 46, 54, 56, 59
Protorthis minima, 77
Protospongia, 67
Pterotheca *cf.* canaliculata, 97
Ptychoparia, 37
matheri, 38
Pyrite, 20
Pyroxene, 18, 20, 28

Quaker Springs, 87, 152
Quartz, 18, 20, 21, 23, 28
Quartz-feldspar, 19
Quartz-pyroxene, 19
Quartzites, 17, 19

Rafinesquina *sp.*, 80
alternata, 76, 96, 97
Rensselaer county, table showing the Lower Cambric series, 68
Retiograptus geinitzianus, 92
Rhinidictya mutabilis, 47
Rock City Falls, 46, 101, 151; fault, 59–60
Rose quartz, 23
Rowlands Mill, 46, 151
Ruedemann, R., Canajoharie shale, 48-51; Control of development and history of Saratoga region by the geology, 168–70; Paleozoic rocks of the eastern trough, 66–99; Relation of the Saratoga mineral springs to structure of the shale belt of the upper Hudson valley, 165-67; Structural geology of the shale belt, 99–115; work on Schuylerville quadrangle, 6; classifying and mapping shales, 6; cited, 42, 48, 74, 81, 152, 157
—— & Cushing, H. P., Historical geology, 135–48
Rysedorph hill, 81
Rysedorph Hill conglomerate, 66, 80–84, 93, 105, 108, 113, 142

Sacandaga creek, 12
St Clements, 61
St Johnsville, 10
Sand terraces, 14
Sandstones, 7
Saratoga fault, 60, 61–62
Saratoga Graphite Co., 149
Saratoga lake, 15
Saratoga quadrangle, location and character, 6–7; part of, mapped by W. J. Miller, 5
Saugerties, 115
Scapolite, 20

Digitized by Google

Schaghticoke shale, 66, 73–74, 107, 111, 141, 142, 165
Schenectady formation, 51–53
Schists, 17, 18, 21, 22, 23, 25
Schizocrania filosa, 50, 96
Schizocrinus *cf.* nodosus, 97, 98
Schodack Landing, 82, 110, 115
Schodack shales and limestones, 66, 69, 72, 73
Schuchert, Charles, cited, 38, 42
Schuylerville, 74, 107
Schuylerville quadrangle, 6–7, 11
Seely, H. M., cited, 42
Shale belt, structural geology, by R. Ruedemann, 99–115
Shales, 7, 10–12
Siphonotreta *cf.* minnesotensis, 80
Smyth, Charles H., jr, acknowledgments to, 6
Snake hill, 104
Snake Hill beds, 49, 51, 66, 89, 93–99, 100, 102, 105, 108, 109, 111, 142, 165
Snook kill, 101
Solenomya ? insperata, 97
Solenopleura nana, 67
tumida, 67, 72
compacta, 47
South Corinth, 56
Sprakers, 10
Springs fault, 60
Spyroceras bilineatum, 98
Star spring, 62.
Staurograptus dichotomus *var.* apertus, 73
Stenotheca rugosa, 72
Stictoporella cribrosa, 47
Stoller, J. H., cited, 146
Stone quarries, 149
Stose, G. W., cited, 83
Strophomena trentonensis, 47
Structural geology of the shale belt, by R. Ruedemann, 99–115
Structural geology of the western basin, by H. P. Cushing, 53–65
Sturdevant creek, 12
Sulphur waters, 152
Syenite, 16, 17, 21, 26–28, 29

Technophorus cancellatus, 97
Terraces, 14–15
Theresa formation, 31, 32, 35–38, 58, 59, 60, 137
Ticonderoga, 35
Titanite, 20, 21, 23
Topography, 8–15
Törnebohm, A. E., cited, 84
Tourmaline, 23
Trap, 17, 21, 149–50
Trap dikes, 29
Trenton limestone, 31, 66, 76, 139, 165
Trenton limestone, basal, *see* Glens Falls limestone
Trenton shale, 31
Triarthrus becki, 50
Tribes Hill, 10
Tribes Hill limestone, 43
Triblidium cornutaforme, 42
Trilobites, 77
Trinucleus concentricus, 97, 98
Trocholites ammonius, 50
Troy shales, 70

Ulrich, E. O., acknowledgments to, 6; mentioned, 32; cited, 38, 42, 47, 74, 78, 83, 93, 113, 114, 115, 141, 143
Utica beds, 53

Van Hise, P. A., cited, 30
Van Ingen, Gilbert, acknowledgments to, 6; cited, 112
Vanuxem, L., cited, 53
Vermont, Lake, 147
Victory Mills, 104

Walcott, C. D., cited, 7, 38, 72, 76, 79, 90, 108; investigations by, 66
Watertown formation, 138, 139
West Galway fault, 56, 57–59
Western basin, structural geology of, by H. P. Cushing, 53–65
Whiteavesia cincta, 96
cumingsi, 96
Whitehall, 35

Digitized by Google

Whitella elongata, 96
Willard mountain, 84, 86, 87, 103, 106, 112
Willard mountain syncline, 107
Willis, Bailey, cited, 106
Wilton, 150
Woodlawn Park fault, 61
Woodworth, J. B., cited, 7, 92, 104, 105, 115, 134, 146, 147; quoted, 116–18

Zion Hill quartzite, 70
Zircon, 21, 23, 28
Zygospira recurvirostris, 96

Digitized by Google

Digitized by Google

The University of the State of New York

New York State Museum

JOHN M. CLARKE, Director

PUBLICATIONS

Packages will be sent prepaid except when distance or weight renders the same impracticable. On 10 or more copies of any one publication 20% discount will be given. Editions printed are only large enough to meet special claims and probable sales. When the sale copies are exhausted, the price for the few reserve copies is advanced to that charged by second-hand booksellers, in order to limit their distribution to cases of special need. Such prices are inclosed in [ ]. All publications are in paper covers, unless binding is specified. Checks or money orders should be addressed and payable to The University of the State of New York.

Museum annual reports 1847–date. *All in print to* 1894, 50c *a volume,* 75c *in cloth;* 1894–*date, sold in sets only;* 75c *each for octavo volumes; price of quarto volumes on application.*

These reports are made up of the reports of the Director, Geologist, Paleontologist, Botanist and Entomologist, and museum bulletins and memoirs, issued as advance sections of the reports.

Director's annual reports 1904–date.

1904.	138p. 20c.	1909.	230p. 41pl. 2 maps, 4 charts. *Out of print.*
1905.	102p. 23pl. 30c.	1910.	280p. il. 42pl. 50c.
1906.	186p. 41pl. 25c.	1911.	218p. 49pl. 50c.
1907.	212p. 63pl. 50c.	1912.	214p. 50pl. 50c.
1908.	234p. 39pl. map. 40c.		

These reports cover the reports of the State Geologist and of the State Paleontologist. Bound also with the museum reports of which they form a part.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, 8vo; 2, 14–16, 4to.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–84, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

Report	*Price*	*Report*	*Price*	*Report*	*Price*
12 (1892)	$.50	17	$.75	21	$.40
14	.75	18	.75	22	.40
15, 2v.	2	19	.40	23	.45
16	1	20	.50	[*See* Director's annual reports]	

Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with the Director's report.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882–date.

Reports 3–20 bound also with museum reports 40–46, 48–58 of which they form a part. Since 1898 these reports have been issued as bulletins. Reports 3–4, 17 are out of print, other reports with prices are:

Report	*Price*	*Report*	*Price*	*Report*	*Price*
1	$.50	11	$.25	21 (Bul. 104)	$.25
2	.30	12	.25	22 (" 110)	.25
5	.25	13	*Out of print*	23 (" 124)	.75
6	.15	14 (Bul. 23)	.20	24 (" 134)	.35
7	.20	15 (" 31)	.15	25 (" 141)	.35
8	.25	16 (" 36)	.25	26 (" 147)	.35
9	.25	18 (" 64)	.20	27 (" 155)	.40
10	.35	19 (" 67)	.15	28 (" 165)	.40
		20 (" 97)	.40		

Digitized by Google

Reports 2, 8–12 may also be obtained bound in cloth at 25c each in addition to the price given above.

Botanist's annual reports 1867–date.

Bound also with museum reports 21–date of which they form a part; the first Botanist's report appeared in the 21st museum report and is numbered 21. Reports 21–24, 29, 31–41 were not published separately.

Separate reports for 1871–74, 1876, 1888–98 are out of print. Report for 1899 may be had for 20c; 1900 for 50c. Since 1901 these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), in volume 4 of the 56th (1902), in volume 2 of the 57th (1903), in volume 4 of the 58th (1904), in volume 2 of the 59th (1905), in volume 1 of the 60th (1906), in volume 2 of the 61st (1907), 62d (1908), 63d (1909), 64th (1910), 65th (1911) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum Memoir 4.

Museum bulletins 1887–date. 8vo. *To advance subscribers, $2 a year, or $1 a year for division* (1) *geology, economic geology, paleontology, mineralogy; 50c each for division* (2) *general zoology, archeology, miscellaneous,* (3) *botany,* (4) *entomology.*

Bulletins are grouped in the list on the following pages according to divisions.

The divisions to which bulletins belong are as follows:

1 Zoology
2 Botany
3 Economic Geology
4 Mineralogy
5 Entomology
6 "
7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 "
12 "
13 Entomology
14 Geology
15 Economic Geology
16 Archeology
17 Economic Geology
18 Archeology
19 Geology
20 Entomology
21 Geology
22 Archeology
23 Entomology
24 "
25 Botany
26 Entomology
27 "
28 Botany
29 Zoology
30 Economic Geology
31 Entomology
32 Archeology
33 Zoology
34 Geology
35 Economic Geology
36 Entomology
37 "
38 Zoology
39 Paleontology
40 Zoology
41 Archeology
42 Geology
43 Zoology
44 Economic Geology
45 Paleontology
46 Entomology
47 "
48 Geology
49 Paleontology
50 Archeology
51 Zoology
52 Paleontology
53 Entomology
54 Botany
55 Archeology
56 Geology
57 Entomology
58 Mineralogy
59 Entomology
60 Zoology
61 Economic Geology
62 Miscellaneous
63 Geology
64 Entomology
65 Paleontology
66 Miscellaneous
67 Botany
68 Entomology
69 Paleontology
70 Mineralogy
71 Zoology
72 Entomology
73 Archeology
74 Entomology
75 Botany
76 Entomology
77 Geology
78 Archeology
79 Entomology
80 Paleontology
81 Geology
82 "
83 "
84 "
85 Economic Geology
86 Entomology
87 Archeology
88 Zoology
89 Archeology
90 Paleontology
91 Zoology
92 Paleontology
93 Economic Geology
94 Botany
95 Geology
96 "
97 Entomology
98 Mineralogy
99 Paleontology
100 Economic Geology
101 Paleontology
102 Economic Geology
103 Entomology
104 "
105 Botany
106 Geology
107 Geology and Paleontology
108 Archeology
109 Entomology
110 Entomology
111 Geology
112 Economic Geology
113 Archeology
114 Geology
115 Geology
116 Botany
117 Archeology
118 Geology
119 Economic Geology
120 "
121 Director's report for 1907
122 Botany
123 Economic Geology
124 Entomology
125 Archeology
126 Geology
127 "
128 "
129 Entomology
130 Zoology
131 Botany
132 Economic Geology
133 Director's report for 1908
134 Entomology
135 Geology
136 Entomology
137 Geology
138 "
139 Botany
140 Director's report for 1909
141 Entomology
142 Economic Geology
143 "
144 Archeology
145 Geology
146 "
147 Entomology
148 Geology
149 Director's report for 1910
150 Botany
151 Economic Geology
152 Geology
153 "
154 "
155 Entomology
156 "
157 Botany
158 Director's report for 1911
159 Geology
160 "
161 Economic Geology
162 Geology
163 Archeology
164 Director's report for 1912
165 Entomology
166 Economic Geology
167 Botany
168 Geology
169 "
170 "

Digitized by Google

Bulletins are also found with the annual reports of the museum as follows:

Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
12–15	48, v. 1	78	57, v. 2	116	60, v. 1	150	64, v. 2
16,17	50, v. 1	79	57, v. 1, pt 2	117	60, v. 3	151	64, v. 2
18,19	51, v. 1	80	57, v. 1, pt 1	118	60, v. 1	152	64, v. 2
20–25	52, v. 1	81,82	58, v. 3	119–21	61, v. 1	153	64, v. 2
26–31	53, v. 1	83,84	58, v. 1	122	61, v. 2	154	64, v. 2
32–34	54, v. 1	85	58, v. 2	123	61, v. 1	155	65, v. 2
35,36	54, v. 2	86	58, v. 5	124	61, v. 2	156	65, v. 2
37–44	54, v. 3	87–89	58, v. 4	125	62, v. 3	157	65, v. 2
45–48	54, v. 4	90	58, v. 3	126–28	62, v. 1	158	65, v. 1
49–54	55, v. 1	91	58, v. 4	129	62, v. 2	159	65, v. 1
55	56, v. 4	92	58, v. 3	130	62, v. 3	160	65, v. 1
56	56, v. 1	93	58, v. 2	131,132	62, v. 2	161	65, v. 2
57	56, v. 3	94	58, v. 4	133	62, v. 1	162	65, v. 1
58	56, v. 1	95,96	58, v. 1	134	62, v. 2		
59,60	56, v. 3	97	58, v. 5	135	63, v. 1	*Memoir*	
61	56, v. 1	98,99	59, v. 2	136	63, v. 2	2	49, v. 3
62	56, v. 4	100	59, v. 1	137	63, v. 1	3,4	53, v. 2
63	56, v. 2	101	59, v. 2	138	63, v. 1	5,6	57, v. 3
64	56, v. 3	102	59, v. 1	139	63, v. 2	7	57, v. 4
65	56, v. 2	103–5	59, v. 2	140	63, v. 1	8, pt 1	59, v. 3
66,67	56, v. 4	106	59, v. 1	141	63, v. 2	8, pt 2	59, v. 4
68	56, v. 3	107	60, v. 2	142	63, v. 2	9, pt 1	60, v. 4
69	56, v. 2	108	60, v. 3	143	63, v. 2	9, pt 2	62, v. 4
70,71	57, v. 1, pt 1	109,110	60, v. 1	144	64, v. 2	10	60, v. 5
72	57, v. 1, pt 2	111	60, v. 2	145	64, v. 1	11	61, v. 3
73	57, v. 2	112	60, v. 1	146	64, v. 1	12	63, v. 3
74	57, v. 1, pt 2	113	60, v. 3	147	64, v. 2	13	63, v. 4
75	57, v. 2	114	60, v. 1	148	64, v. 2	14, v. 1	65, v. 3
76	57, v. 1, pt 2	115	60, v. 2	149	64, v. 1	14, v. 2	65, v. 4
77	57, v. 1, pt 1						

The figures at the beginning of each entry in the following list indicate its number as a museum bulletin.

Geology and Paleontology. 14 Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co. N. Y., with notes on the iron mines. 38p. il. 7pl. 2 maps. Sept. 1895. Free.

19 Merrill, F. J. H. Guide to the Study of the Geological Collections of the New York State Museum. 164p. 119pl. map. Nov. 1898. *Out of print.*

21 Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sept. 1898. Free.

34 Cumings, E. R. Lower Silurian System of Eastern Montgomery County; Prosser, C. S. Notes on the Stratigraphy of Mohawk Valley and Saratoga County, N. Y. 74p. 14pl. map. May 1900. 15c.

39 Clarke, J. M.; Simpson, G. B. & Loomis, F. B. Paleontologic Papers 1. 72p. il. 16pl. Oct. 1900. 15c.

Contents: Clarke, J. M. A Remarkable Occurrence of Orthoceras in the Oneonta Beds of the Chenango Valley, N. Y.
—— Paropsonema cryptophya; a Peculiar Echinoderm from the Intumescens-zone (Portage Beds) of Western New York.
—— Dictyonine Hexactinellid Sponges from the Upper Devonic of New York.
—— The Water Biscuit of Squaw Island, Canandaigua Lake, N. Y.
Simpson, G. B. Preliminary Descriptions of New Genera of Paleozoic Rugose Corals.
Loomis, F. B. Siluric Fungi from Western New York.

42 Ruedemann, Rudolf. Hudson River Beds near Albany and their Taxonomic Equivalents. 116p. 2pl. map. Apr. 1901. 25c.

45 Grabau, A. W. Geology and Paleontology of Niagara Falls and Vicinity. 286p. il. 18pl. map. Apr. 1901. 65c; *cloth*, 90c.

48 Woodworth, J. B. Pleistocene Geology of Nassau County and Borough of Queens. 58p. il. 8pl. map. Dec. 1901. 25c.

49 Ruedemann, Rudolf; Clarke, J. M. & Wood, Elvira. Paleontologic Papers 2. 240p. 13pl. Dec. 1901. *Out of print.*

Contents: Ruedemann, Rudolf. Trenton Conglomerate of Rysedorph Hill.
Clarke, J. M. Limestones of Central and Western New York Interbedded with Bituminous Shales of the Marcellus Stage.
Wood, Elvira. Marcellus Limestones of Lancaster, Erie Co., N. Y.
Clarke, J. M. New Agelacrinites.
—— Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonic of New York, Ireland and the Rhineland.

52 Clarke, J. M. Report of the State Paleontologist 1901. 280p. il. 10pl. map, 1 tab. July 1902. 40c.

56 Merrill, F. J. H. Description of the State Geologic Map of 1901. 42p. 2 maps, tab. Nov. 1902. Free.

Digitized by Google

63 Clarke, J. M. & Luther, D. D. Stratigraphy of Canandaigua and Naples Quadrangles. 78p. map. June 1904. 25c.

65 Clarke, J. M. Catalogue of Type Specimens of Paleozoic Fossils in the New York State Museum. 848p. May 1903. $1.20, *cloth.*

69 —— Report of the State Paleontologist 1902. 464p. 52pl. 7 maps. Nov. 1903. $1, *cloth.*

77 Cushing, H. P. Geology of the Vicinity of Little Falls, Herkimer Co. 98p. il. 15pl. 2 maps. Jan. 1905. 30c.

80 Clarke, J. M. Report of the State Paleontologist 1903. 396p. 29pl. 2 maps. Feb. 1905. 85c, *cloth.*

81 Clarke, J. M. & Luther, D. D. Watkins and Elmira Quadrangles. 32p. map. Mar. 1905. 25c.

82 —— Geologic Map of the Tully Quadrangle. 40p. map. Apr. 1905. 20c.

83 Woodworth, J. B. Pleistocene Geology of the Mooers Quadrangle. 62p. 25pl. map. June 1905. 25c.

84 —— Ancient Water Levels of the Champlain and Hudson Valleys. 206p. il. 11pl. 18 maps. July 1905. 45c.

90 Ruedemann, Rudolf. Cephalopoda of Beekmantown and Chazy Formations of Champlain Basin. 224p. il. 38pl. May 1906. 75c, *cloth.*

92 Grabau, A. W. Guide to the Geology and Paleontology of the Schoharie Region. 314p. il. 26pl. map. Apr. 1906. 75c, *cloth.*

95 Cushing, H. P. Geology of the Northern Adirondack Region. 188p. 15pl. 3 maps. Sept. 1905. 30c.

96 Ogilvie, I. H. Geology of the Paradox Lake Quadrangle. 54p. il. 17pl. map. Dec. 1905. 30c.

99 Luther, D. D. Geology of the Buffalo Quadrangle. 32p. map. May 1906. 20c.

101 —— Geology of the Penn Yan-Hammondsport Quadrangles. 28p. map. July 1906. *Out of print.*

106 Fairchild, H. L. Glacial Waters in the Erie Basin. 88p. 14pl. 9 maps. Feb. 1907. *Out of print.*

107 Woodworth, J. B.; Hartnagel, C. A.; Whitlock, H. P.; Hudson, G. H.; Clarke, J. M.; White, David & Berkey, C. P. Geological Papers. 388p. 54pl. map. May 1907. 90c, *cloth.*

Contents: Woodworth, J. B. Postglacial Faults of Eastern New York.
Hartnagel, C. A. Stratigraphic Relations of the Oneida Conglomerate.
—— Upper Siluric and Lower Devonic Formations of the Skunnemunk Mountain Region.
Whitlock, H. P. Minerals from Lyon Mountain, Clinton Co.
Hudson, G. H. On Some Pelmatozoa from the Chazy Limestone of New York.
Clarke, J. M. Some New Devonic Fossils.
—— An Interesting Style of Sand-filled Vein.
—— Eurypterus Shales of the Shawangunk Mountains in Eastern New York.
White, David. A Remarkable Fossil Tree Trunk from the Middle Devonic of New York.
Berkey, C. P. Structural and Stratigraphic Features of the Basal Gneisses of the Highlands.

111 Fairchild, H. L. Drumlins of New York. 60p. 28pl. 19 maps. July 1907. *Out of print.*

114 Hartnagel, C. A. Geologic Map of the Rochester and Ontario Beach Quadrangles. 36p. map. Aug. 1907. 20c.

115 Cushing, H. P. Geology of the Long Lake Quadrangle. 88p. 20pl. map. Sept. 1907. *Out of print.*

118 Clarke, J. M. & Luther, D. D. Geologic Maps and Descriptions of the Portage and Nunda Quadrangles including a map of Letchworth Park. 50p. 16pl. 4 maps. Jan. 1908. 35c.

126 Miller, W. J. Geology of the Remsen Quadrangle. 54p. il. 11pl. map. Jan. 1909. 25c.

127 Fairchild, H. L. Glacial Waters in Central New York. 64p. 27pl. 15 maps. Mar. 1909. 40c.

128 Luther, D. D. Geology of the Geneva-Ovid Quadrangles. 44p. map. Apr. 1909. 20c.

135 Miller, W. J. Geology of the Port Leyden Quadrangle, Lewis County, N. Y. 62p. il. 11pl. map. Jan. 1910. 25c.

137 Luther, D. D. Geology of the Auburn-Genoa Quadrangles. 36p. map. Mar. 1910. 20c.

138 Kemp, J. F. & Ruedemann, Rudolf. Geology of the Elizabethtown and Port Henry Quadrangles. 176p. il. 20pl. 3 maps. Apr. 1910. 40c.

Digitized by Google

145 Cushing, H. P.; Fairchild, H. L.; Ruedemann, Rudolf & Smyth, C. H. Geology of the Thousand Islands Region. 194p. il. 62pl. 6 maps. Dec. 1910. 75c.
146 Berkey, C. P. Geologic Features and Problems of the New York City (Catskill) Aqueduct. 286p. il. 38pl. maps. Feb. 1911. 75c; *cloth*, $1.
148 Gordon, C. E. Geology of the Poughkeepsie Quadrangle. 122p. il. 26pl. map. Apr. 1911. 30c.
152 Luther, D. D. Geology of the Honeoye-Wayland Quadrangles. 30p. map. Oct. 1911. 20c.
153 Miller, William J. Geology of the Broadalbin Quadrangle, Fulton-Saratoga Counties, New York. 66p. il. 8 pl. map. Dec. 1911. 25c.
154 Stoller, James H. Glacial Geology of the Schenectady Quadrangle. 44p. 9 pl. map. Dec. 1911. 20c.
159 Kemp, James F. The Mineral Springs of Saratoga. 80p. il. 3pl. Apr. 1912. 15c.
160 Fairchild, H. L. Glacial Waters in the Black and Mohawk Valleys. 48p. il. 8pl. 14 maps. May 1912. 50c.
162 Ruedemann, Rudolf. The Lower Siluric Shales of the Mohawk Valley. 152p. il. 15pl. Aug. 1912. 35c.
168 Miller, William J. Geological History of New York State. 130p. 43pl. 10 maps. Dec. 1913. 40c.
169 Cushing, H. P. & Ruedemann, Rudolf. Geology of Saratoga Springs and Vicinity. 178p. il. 20pl. map. Feb. 1914. 40c.
170 Miller, William J. Geology of the North Creek Quadrangle. 90p. il. 14pl. Feb. 1914. 25c.
Luther, D. D. Geology of the Attica and Depew Quadrangles. *In press.*
Luther, D. D. Geology of the Phelps Quadrangle. *In preparation.*
Whitnall, H. O. Geology of the Morrisville Quadrangle. *Prepared.*
Hopkins, T. C. Geology of the Syracuse Quadrangle. *In press.*
Hudson, G. H. Geology of Valcour Island. *In preparation.*
Economic Geology. 3 Smock, J. C. Building Stone in the State of New York. 154p. Mar. 1888. *Out of print.*
7 —— First Report on the Iron Mines and Iron Ore Districts in the State of New York. 78p. map. June 1889. *Out of print.*
10 —— Building Stone in New York. 210p. map, tab. Sept. 1890. 40c.
11 Merrill, F. J. H. Salt and Gypsum Industries of New York. 94p. 12pl. 2 maps, 11 tab. Apr. 1893. [50c]
12 Ries, Heinrich. Clay Industries of New York. 174p. il. 1pl. map. Mar. 1895. 30c.
15 Merrill, F. J. H. Mineral Resources of New York. 240p. 2 maps. Sept. 1895. [50c]
17 —— Road Materials and Road Building in New York. 52p. 14pl. 2 maps. Oct. 1897. 15c.
30 Orton, Edward. Petroleum and Natural Gas in New York. 136p. il. 3 maps. Nov. 1899. 15c.
35 Ries, Heinrich. Clays of New York; their Properties and Uses. 456p. 140pl. map. June 1900. *Out of print.*
44 —— Lime and Cement Industries of New York; Eckel, E. C. Chapters on the Cement Industry. 332p. 101pl. 2 maps. Dec. 1901. 85c, *cloth.*
61 Dickinson, H. T. Quarries of Bluestone and Other Sandstones in New York. 114p. 18pl. 2 maps. Mar. 1903. 35c.
85 Rafter, G. W. Hydrology of New York State. 902p. il. 44pl. 5 maps. May 1905. $1.50, *cloth.*
93 Newland, D. H. Mining and Quarry Industry of New York. 78p. July 1905. *Out of print.*
100 McCourt, W. E. Fire Tests of Some New York Building Stones. 40p. 26pl. Feb. 1906. 15c.
102 Newland, D. H. Mining and Quarry Industry of New York 1905. 162p. June 1906. 25c.
112 —— Mining and Quarry Industry of New York 1906. 82p. July 1907. *Out of print.*
119 —— & Kemp, J. F. Geology of the Adirondack Magnetic Iron Ores with a Report on the Mineville-Port Henry Mine Group. 184p. 14pl. 8 maps. Apr. 1908. 35c.
120 Newland, D. H. Mining and Quarry Industry of New York 1907. 82p. July 1908. *Out of print.*

Digitized by Google

123 —— & Hartnagel, C. A. Iron Ores of the Clinton Formation in New York State. 76p. il. 14pl. 3 maps. Nov. 1908. 25c.
132 Newland, D. H. Mining and Quarry Industry of New York 1908. 98p. July 1909. 15c.
142 —— Mining and Quarry Industry of New York for 1909. 98p. Aug. 1910. 15c.
143 —— Gypsum Deposits of New York. 94p. 20pl. 4 maps. Oct. 1910 35c.
151 —— Mining and Quarry Industry of New York 1910. 82p. June 1911. 15c.
161 —— Mining and Quarry Industry of New York 1911. 114p. July 1912. 20c.
166 —— Mining and Quarry Industry of New York 1912. 114p. August 1913. 20c.

Mineralogy. 4 Nason, F. L. Some New York Minerals and their Localities. 22p. 1pl. Aug. 1888. Free.
58 Whitlock, H. P. Guide to the Mineralogic Collections of the New York State Museum. 150p. il. 39pl. 11 models. Sept. 1902. 40c.
70 —— New York Mineral Localities. 110p. Oct. 1903. 20c.
98 —— Contributions from the Mineralogic Laboratory. 38p. 7pl. Dec. 1905. *Out of print.*

Zoology. 1 Marshall, W. B. Preliminary List of New York Unionidae 20p. Mar. 1892. Free.
9 —— Beaks of Unionidae Inhabiting the Vicinity of Albany, N. Y. 30p. 1pl. Aug. 1890. Free.
29 Miller, G. S., jr. Preliminary List of New York Mammals. 124p. Oct. 1899. 15c.
33 Farr, M. S. Check List of New York Birds. 224p. Apr. 1900. 25c.
38 Miller, G. S., jr. Key to the Land Mammals of Northeastern North America. 106p. Oct. 1900. *Out of print.*
40 Simpson, G. B. Anatomy and Physiology of Polygyra albolabris and Limax maximus and Embryology of Limax maximus. 82p. 28pl. Oct. 1901. 25c.
43 Kellogg, J. L. Clam and Scallop Industries of New York. 36p. 2pl. map. Apr. 1901. Free.
51 Eckel, E. C. & Paulmier, F. C. Catalogue of Reptiles and Batrachians of New York. 64p. il. 1pl. Apr. 1902. *Out of print.*

Eckel, E. C. Serpents of Northeastern United States.
Paulmier, F. C. Lizards, Tortoises and Batrachians of New York.

60 Bean, T. H. Catalogue of the Fishes of New York. 784p. Feb. 1903. $1, *cloth.*
71 Kellogg, J. L. Feeding Habits and Growth of Venus mercenaria. 30p. 4pl. Sept. 1903. Free.
88 Letson, Elizabeth J. Check List of the Mollusca of New York. 116p. May 1905. 20c.
91 Paulmier, F. C. Higher Crustacea of New York City. 78p. il. June 1905. 20c.
130 Shufeldt, R. W. Osteology of Birds. 382p. il. 26pl. May 1909. 50c.

Entomology. 5 Lintner, J. A. White Grub of the May Beetle. 34p. il. Nov. 1888. Free.
6 —— Cut-worms. 38p. il. Nov. 1888. Free.
13 —— San José Scale and Some Destructive Insects of New York State. 54p. 7pl. Apr. 1895. 15c.
20 Felt, E. P. Elm Leaf Beetle in New York State. 46p. il. 5pl. June 1898. Free.

See 57.

23 —— 14th Report of the State Entomologist 1898. 150p. il. 9pl. Dec. 1898. 20c.
24 —— Memorial of the Life and Entomologic Work of J. A. Lintner Ph.D. State Entomologist 1874–98; Index to Entomologist's Reports 1–13. 316p. 1pl. Oct. 1899. 35c.

Supplement to 14th report of the State Entomologist.

25 —— Collection, Preservation and Distribution of New York Insects. 36p. il. Apr. 1899. *Out of print.*
27 —— Shade Tree Pests in New York State. 26p. il. 5pl. May 1899. Free.

Digitized by Google

31 —— 15th Report of the State Entomologist 1899. 128p. June 1900. 15c.

36 —— 16th Report of the State Entomologist 1900. 118p. 16pl. Mar. 1901. 25c.

37 —— Catalogue of Some of the More Important Injurious and Beneficial Insects of New York State. 54p. il. Sept. 1900. Free.

46 —— Scale Insects of Importance and a List of the Species in New York State. 94p. il. 15pl. June 1901. 25c.

47 Needham, J. G. & Betten, Cornelius. Aquatic Insects in the Adirondacks. 234p. il. 36pl. Sept. 1901. 45c.

53 Felt, E. P. 17th Report of the State Entomologist 1901. 232p. il. 6pl. Aug. 1902. *Out of print.*

57 —— Elm Leaf Beetle in New York State. 46p. il. 8pl. Aug. 1902. *Out of print.*

This is a revision of Bulletin 20 containing the more essential facts observed since that was prepared.

59 —— Grapevine Root Worm. 40p. 6pl. Dec. 1902. 15c.

See 72.

64 —— 18th Report of the State Entomologist 1902. 110p. 6pl. May 1903. 20c.

68 Needham, J. G. *& others.* Aquatic Insects in New York. 322p. 52pl. Aug. 1903. 80c, *cloth.*

72 Felt, E. P. Grapevine Root Worm. 58p. 13pl. Nov. 1903. 20c.

This is a revision of Bulletin 59 containing the more essential facts observed since that was prepared.

74 —— & Joutel, L. H. Monograph of the Genus Saperda. 88p. 14pl. June 1904. 25c.

76 Felt, E. P. 19th Report of the State Entomologist 1903. 150p. 4pl. 1904. 15c.

79 —— Mosquitos or Culicidae of New York. 164p. il. 57pl. tab. Oct. 1904. 40c.

86 Needham, J. G. *& others.* May Flies and Midges of New York. 352p. il. 37pl. June 1905. 80c, *cloth.*

97 Felt, E. P. 20th Report of the State Entomologist 1904. 246p. il. 19pl. Nov. 1905. 40c.

103 —— Gipsy and Brown Tail Moths. 44p. 10pl. July 1906. 15c.

104 —— 21st Report of the State Entomologist 1905. 144p. 10pl. Aug. 1906. 25c.

109 —— Tussock Moth and Elm Leaf Beetle. 34p. 8pl. Mar. 1907. 20c.

110 —— 22d Report of the State Entomologist 1906. 152p. 3pl. June 1907. 25c.

124 —— 23d Report of the State Entomologist 1907. 542p. il. 44pl. Oct. 1908. 75c.

129 —— Control of Household Insects. 48p. il. May 1909. *Out of print.*

134 —— 24th Report of the State Entomologist 1908. 208p. il. 17pl. Sept. 1909. 35c.

136 —— Control of Flies and Other Household Insects. 56p. il. Feb. 1910. 15c.

This is a revision of Bulletin 129 containing the more essential facts observed since that was prepared.

141 Felt, E. P. 25th Report of the State Entomologist 1909. 178p. il. 22pl. July 1910. 35c.

147 —— 26th Report of the State Entomologist 1910. 182p. il. 35pl. Mar. 1911. 35c.

155 —— 27th Report of the State Entomologist 1911. 198p. il. 27pl. Jan. 1912. 40c.

156 —— Elm Leaf Beetle and White-Marked Tussock Moth. 35p. 8pl. Jan. 1912. 20c.

165 —— 28th Report of the State Entomologist 1912. 266p. 14pl. July 1913. 40c.

Needham, J. G. Monograph on Stone Flies. *In preparation.*

Botany. 2 Peck, C. H. Contributions to the Botany of the State of New York. 72p. 2pl. May 1887. *Out of print.*

Digitized by Google

8 —— Boleti of the United States. 98p. Sept. 1889. *Out of print.*
25 —— Report of the State Botanist 1898. 76p. 5pl. Oct. 1899. *Out of print.*
28 —— Plants of North Elba. 206p. map. June 1899. 20c.
54 —— Report of the State Botanist 1901. 58p. 7pl. Nov. 1902. 40c.
67 —— Report of the State Botanist 1902. 196p. 5pl. May 1903. 50c.
75 —— Report of the State Botanist 1903. 70p. 4pl. 1904. 40c.
94 —— Report of the State Botanist 1904. 60p. 10pl. July 1905. 40c.
105 —— Report of the State Botanist 1905. 108p. 12pl. Aug. 1906. 50c.
116 —— Report of the State Botanist 1906. 120p. 6pl. July 1907. 35c.
122 —— Report of the State Botanist 1907. 178p. 5pl. Aug. 1908. 40c.
131 —— Report of the State Botanist 1908. 202p. 4pl. July 1909. 40c.
139 —— Report of the State Botanist 1909. 116p. 10pl. May 1910. 45c.
150 —— Report of the State Botanist 1910. 100p. 5pl. May 1911. 30c.
157 —— Report of the State Botanist 1911. 139p. 9pl. Mar. 1912. 35c.
167 —— Report of the State Botanist 1912. 138p. 4pl. Sept. 1913. 30c.

Archeology. 16 Beauchamp, W. M. Aboriginal Chipped Stone Implements of New York. 86p. 23pl. Oct. 1897. 25c.
18 —— Polished Stone Articles Used by the New York Aborigines. 104p. 35pl. Nov. 1897. 25c.
22 —— Earthenware of the New York Aborigines. 78p. 33pl. Oct. 1898. 25c.
32 —— Aboriginal Occupation of New York. 190p. 16pl. 2 maps. Mar. 1900. 30c.
41 —— Wampum and Shell Articles Used by New York Indians. 166p. 28pl. Mar. 1901. 30c.
50 —— Horn and Bone Implements of the New York Indians. 112p. 43pl. Mar. 1902. 30c.
55 —— Metallic Implements of the New York Indians. 94p. 38pl. June 1902. 25c.
73 —— Metallic Ornaments of the New York Indians. 122p. 37pl. Dec. 1903. 30c.
78 —— History of the New York Iroquois. 340p. 17pl. map. Feb. 1905. 75c, *cloth.*
87 —— Perch Lake Mounds. 84p. 12pl. Apr. 1905. *Out of print.*
89 —— Aboriginal Use of Wood in New York. 190p. 35pl. June 1905. 35c.
108 —— Aboriginal Place Names of New York. 336p. May 1907. 40c.
113 —— Civil, Religious and Mourning Councils and Ceremonies of Adoption. 118p. 7pl. June 1907. 25c.
117 Parker, A. C. An Erie Indian Village and Burial Site. 102p. 38pl. Dec. 1907. 30c.
125 Converse, H. M. & Parker, A. C. Iroquois Myths and Legends. 196p. il. 11pl. Dec. 1908. 50c.
144 Parker, A. C. Iroquois Uses of Maize and Other Food Plants. 120p. il. 31pl. Nov. 1910. 30c.
163 —— The Code of Handsome Lake. 144p. 23pl. Nov. 1912. 25c.

Miscellaneous. 62 Merrill, F. J. H. Directory of Natural History Museums in United States and Canada. 236p. Apr. 1903. 30c.
66 Ellis, Mary. Index to Publications of the New York State Natural History Survey and New York State Museum 1837–1902. 418p. June 1903. 75c, *cloth.*

Museum memoirs 1889–date. 4to.
1 Beecher, C. E. & Clarke, J. M. Development of Some Silurian Brachiopoda. 96p. 8pl. Oct. 1889. $1.
2 Hall, James & Clarke, J. M. Paleozoic Reticulate Sponges. 350p. il. 70pl. 1898. $2, *cloth.*
3 Clarke, J. M. The Oriskany Fauna of Becraft Mountain, Columbia Co., N. Y. 128p. 9pl. Oct. 1900. 80c.
4 Peck, C. H. N. Y. Edible Fungi, 1895–99. 106p. 25pl. Nov. 1900. [$1.25]

This includes revised descriptions and illustrations of fungi reported in the 49th, 51st and 52d reports of the State Botanist.

Digitized by Google

5 Clarke, J. M. & Ruedemann, Rudolf. Guelph Formation and Fauna of New York State. 196p. 21pl. July 1903. $1.50, *cloth.*

6 Clarke, J. M. Naples Fauna in Western New York. 268p. 26pl. map. 1904. $2, *cloth.*

7 Ruedemann, Rudolf. Graptolites of New York. Pt 1 Graptolites of the Lower Beds. 350p. 17pl. Feb. 1905. $1.50, *cloth.*

8 Felt, E. P. Insects Affecting Park and Woodland Trees. v.1. 460p. il. 48pl. Feb. 1906. $2.50, *cloth*; v. 2. 548p. il. 22pl. Feb. 1907. $2, *cloth.*

9 Clarke, J. M. Early Devonic of New York and Eastern North America. Pt 1. 366p. il. 70pl. 5 maps. Mar. 1908. $2.50, *cloth*; Pt 2. 250p. il. 36pl. 4 maps. Sept. 1909. $2, *cloth.*

10 Eastman, C. R. The Devonic Fishes of the New York Formations. 236p. 15pl. 1907. $1.25, *cloth.*

11 Ruedemann, Rudolf. Graptolites of New York. Pt 2 Graptolites of the Higher Beds. 584p. il. 31pl. 2 tab. Apr. 1908. $2.50, *cloth.*

12 Eaton, E. H. Birds of New York. v. 1. 501p. il. 42pl. Apr. 1910. $3, *cloth*; v. 2, *in press.*

13 Whitlock, H. P. Calcites of New York. 190p. il. 27pl. Oct. 1910. $1, *cloth.*

14 Clarke, J. M. & Ruedemann, Rudolf. The Eurypterida of New York. v. 1. Text. 440p. il. v. 2 Plates. 188p. 88pl. Dec. 1912. $4, *cloth.*

Natural History of New York. 30v. il. pl. maps. 4to. Albany 1842–94.

DIVISION 1 ZOOLOGY. De Kay, James E. Zoology of New York; or, The New York Fauna; comprising detailed descriptions of all the animals hitherto observed within the State of New York with brief notices of those occasionally found near its borders, and accompanied by appropriate illustrations. 5v. il. pl. maps. sq. 4to. Albany 1842–44. *Out of print.*

Historical introduction to the series by Gov. W. H. Seward. 178p.

v. 1 pt1 Mammalia. 131 + 46p. 33pl. 1842.

300 copies with hand-colored plates.

v. 2 pt2 Birds. 12 + 380p. 141pl. 1844.

Colored plates.

v. 3 pt3 Reptiles and Amphibia. 7 + 98p. pt 4 Fishes. 15 + 415p. 1842.

pt 3–4 bound together.

v. 4 Plates to accompany v. 3. Reptiles and Amphibia. 23pl. Fishes. 79pl. 1842.

300 copies with hand-colored plates.

v. 5 pt5 Mollusca. 4 + 271p. 40pl. pt 6 Crustacea. 70p. 13pl. 1843–44.

Hand-colored plates; pt5–6 bound together.

DIVISION 2 BOTANY. Torrey, John. Flora of the State of New York; comprising full descriptions of all the indigenous and naturalized plants hitherto discovered in the State, with remarks on their economical and medical properties. 2v. il. pl. sq. 4to. Albany 1843. *Out of print.*

v. 1 Flora of the State of New York. 12 + 484p. 72pl. 1843.

300 copies with hand-colored plates.

v. 2 Flora of the State of New York. 572p. 89pl. 1843.

300 copies with hand-colored plates.

DIVISION 3 MINERALOGY. Beck, Lewis C. Mineralogy of New York; comprising detailed descriptions of the minerals hitherto found in the State of New York, and notices of their uses in the arts and agriculture. il. pl. sq. 4to. Albany 1842. *Out of print.*

v. 1 pt1 Economical Mineralogy. pt2 Descriptive Mineralogy. 24 + 536p. 1842.

8 plates additional to those printed as part of the text.

DIVISION 4 GEOLOGY. Mather, W. W.; Emmons, Ebenezer; Vanuxem, Laidner & Hall, James. Geology of New York. 4v. il. pl. sq. 4to. Albany 1842–43. *Out of print.*

v. 1 pt1 Mather, W. W. First Geological District. 37 + 653p. 46pl. 1843.

v. 2 pt2 Emmons, Ebenezer. Second Geological District. 10 + 437p. 17pl. 1842.

Digitized by Google

v. 3 pt3 Vanuxem, Lardner. Third Geological District. 306p. 1842.
v. 4 pt4 Hall, James. Fourth Geological District. 22 + 683p. 19pl. map. 1843.

DIVISION 5 AGRICULTURE. Emmons, Ebenezer. Agriculture of New York; comprising an account of the classification, composition and distribution of the soils and rocks and the natural waters of the different geological formations, together with a condensed view of the meteorology and agricultural productions of the State. 5v. il. pl. sq. 4to. Albany 1846–54. *Out of print.*

v. 1 Soils of the State, Their Composition and Distribution. 11 + 371p. 21pl. 1846.
v. 2 Analysis of Soils, Plants, Cereals, etc. 8 + 343 + 46p. 42pl. 1849.
With hand-colored plates.

v. 3 Fruits, etc. 8 + 340p. 1851.
v. 4 Plates to accompany v. 3. 95pl. 1851.
Hand-colored.

v. 5 Insects Injurious to Agriculture. 8 + 272p. 50pl. 1854.
With hand-colored plates.

DIVISION 6 PALEONTOLOGY. Hall, James. Palaeontology of New York. 8v. il. pl. sq. 4to. Albany 1847–94. *Bound in cloth.*

v. 1 Organic Remains of the Lower Division of the New York System. 23 + 338p. 99pl. 1847. *Out of print.*
v. 2 Organic Remains of Lower Middle Division of the New York System. 8 + 362p. 104pl. 1852. *Out of print.*
v. 3 Organic Remains of the Lower Helderberg Group and the Oriskany Sandstone. pt 1, text. 12 + 532p. 1859. [$3.50]
—— pt 2. 142pl. 1861. [$2.50]
v. 4 Fossil Brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 11 + 1 + 428p. 69pl. 1867. $2.50.
v. 5 pt 1 Lamellibranchiata 1. Monomyaria of the Upper Helderbergs, Hamilton and Chemung Groups. 18 + 268p. 45pl. 1884. $2.50.
—— —— Lamellibranchiata 2. Dimyaria of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 62 + 293p. 51pl. 1885. $2.50.
—— pt 2 Gasteropoda, Pteropoda and Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 2v. 1879. v. 1, text. 15 + 492p.; v.2. 120pl. $2.50 for 2 v.
—— & Simpson, George B. v. 6 Corals and Bryozoa of the Lower and Upper Helderberg and Hamilton Groups. 24 + 298p. 67pl. 1887. $2.50.
—— & Clarke, John M. v. 7 Trilobites and Other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. 64 + 236p. 46pl. 1888. Cont. supplement to v. 5, pt 2. Pteropoda, Cephalopoda and Annelida. 42p. 18pl. 1888. $2.50.
—— & Clarke, John M. v. 8 pt 1 Introduction to the Study of the Genera of the Paleozoic Brachiopoda. 16 + 367p. 44pl. 1892. $2.50.
—— & Clarke, John M. v. 8 pt 2 Paleozoic Brachiopoda. 16 + 394p. 64pl. 1894. $2.50.

Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. 8vo. 1853.

Handbooks 1893–date.

New York State Museum. 52p. il. 1902. Free.
Outlines, history and work of the museum with list of staff 1902.

Paleontology. 12p. 1899. *Out of print.*
Brief outline of State Museum work in paleontology under heads: Definition; Relation to biology; Relation to stratigraphy; History of paleontology in New York.

Guide to Excursions in the Fossiliferous Rocks of New York. 124p. 1899. *Out of print.*
Itineraries of 32 trips covering nearly the entire series of Paleozoic rocks, prepared specially for the use of teachers and students desiring to acquaint themselves more intimately with the classic rocks of this State.

Digitized by Google

Entomology. 16p. 1899. *Out of print.*
Economic Geology. 44p. 1904. Free.
Insecticides and Fungicides. 20p. 1909. Free.
Classification of New York Series of Geologic Formations. 32p. 1903. *Out of print.* Revised edition. 96p. 1912. Free.
Geologic maps. Merrill, F. J. H. Economic and Geologic Map of the State of New York: issued as part of Museum Bulletin 15 and 48th Museum Report, v. 1. 59 x 67 cm. 1894. Scale 14 miles to 1 inch. 15c.
—— Map of the State of New York Showing the Location of Quarries of Stone Used for Building and Road Metal. 1897. *Out of print.*
—— Map of the State of New York Showing the Distribution of the Rocks Most Useful for Road Metal. 1897. *Out of print.*
—— Geologic Map of New York. 1901. Scale 5 miles to 1 inch. *In atlas form* $3. *Lower Hudson sheet* 60c.

The lower Hudson sheet, geologically colored, comprises Rockland, Orange, Dutchess, Putnam, Westchester, New York, Richmond, Kings, Queens and Nassau counties, and parts of Sullivan, Ulster and Suffolk counties; also northeastern New Jersey and part of western Connecticut.

—— Map of New York Showing the Surface Configuration and Water Sheds. 1901. Scale 12 miles to 1 inch. 15c.
—— Map of the State of New York Showing the Location of Its Economic Deposits. 1904. Scale 12 miles to 1 inch. 15c.
Geologic maps on the United States Geological Survey topographic base. Scale 1 in. = 1 m. Those marked with an asterisk have also been published separately.
*Albany county. 1898. *Out of print.*
Area around Lake Placid. 1898.
Vicinity of Frankfort Hill [parts of Herkimer and Oneida counties]. 1899.
Rockland county. 1899.
Amsterdam quadrangle. 1900.
*Parts of Albany and Rensselaer counties. 1901. *Out of print.*
*Niagara river. 1901. 25c.
Part of Clinton county. 1901.
Oyster Bay and Hempstead quadrangles on Long Island. 1901.
Portions of Clinton and Essex counties. 1902.
Part of town of Northumberland, Saratoga co. 1903.
Union Springs, Cayuga county and vicinity. 1903.
*Olean quadrangle. 1903. Free.
*Becraft Mt with 2 sheets of sections. (Scale 1 in. = ½ m.) 1903. 20c.
*Canandaigua-Naples quadrangles. 1904. 20c.
*Little Falls quadrangle. 1905. Free.
*Watkins-Elmira quadrangles. 1905. 20c.
*Tully quadrangle. 1905. Free.
*Salamanca quadrangle. 1905. Free.
*Mooers quadrangle. 1905. Free.
Paradox Lake quadrangle. 1905.
*Buffalo quadrangle. 1906. Free.
*Penn Yan-Hammondsport quadrangles. 1906. 20c.
*Rochester and Ontario Beach quadrangles. 20c.
*Long Lake quadrangle. Free.
*Nunda-Portage quadrangles. 20c.
*Remsen quadrangle. 1908. Free.
*Geneva-Ovid quadrangles. 1909. 20c.
*Port Leyden quadrangle. 1910. Free.
*Auburn-Genoa quadrangles. 1910. 20c.
*Elizabethtown and Port Henry quadrangles. 1910. 15c.
*Alexandria Bay quadrangle. Free.
*Cape Vincent quadrangle. Free.
*Clayton quadrangle. Free.
*Grindstone quadrangle. Free.
*Theresa quadrangle. Free.
*Poughkeepsie quadrangle. Free.
*Honeoye-Wayland quadrangle. 20c
*Broadalbin quadrangle. Free.
*Schenectady quadrangle. Free.

Digitized by Google

Digitized by Google

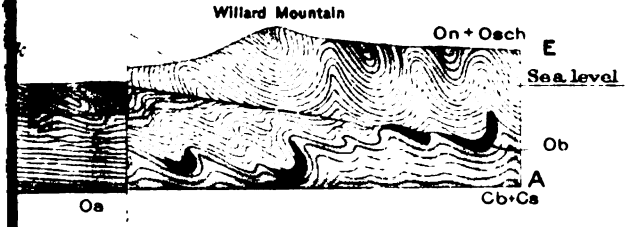
Geologic map of the Saratoga-Schuylerville quadrangles

and Section

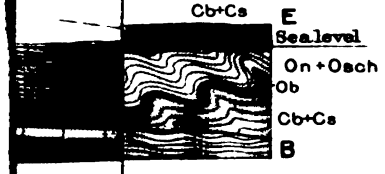
Digitized by Google

Digitized by Google

DRANG
uch = 1 mi



ROSS T



THE S

Digitized by Google

Digitized by Google

11,983

University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the act of August 24, 1912

Published fortnightly

No. 561 ALBANY, N. Y. FEBRUARY 15, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 170

GEOLOGY OF THE NORTH CREEK QUADRANGLE, WARREN COUNTY, NEW YORK

BY

WILLIAM J. MILLER

	PAGE
Introduction	5
General topography and geology	6
Rocks of the region	8
Structural features	45
Topography	61
Glacial and postglacial geology	65
Summary of geological history	76
Economic geology	78
Index	87

ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

1914

M36c-Mr13-1500

Digitized by Google

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of the University

(March 15, 1914)

With years when terms expire

1917 St Clair McKelway M.A. LL.D. D.C.L. L.H.D.
Chancellor Brooklyn
1914 Pliny T. Sexton LL.B. LL.D. *Vice Chancellor* Palmyra
1915 Albert Vander Veer M.D. M.A. Ph.D. LL.D. Albany
1922 Chester S. Lord M.A. LL.D. - - - - - New York
1918 William Nottingham M.A. Ph.D. LL.D. - - Syracuse
1921 Francis M. Carpenter - - - - - - - - Mount Kisco
1923 Abram I. Elkus LL.B. D.C.L. - - - - - New York
1924 Adelbert Moot - - - - - - - - - - Buffalo
1925 Charles B. Alexander M.A. LL.B. LL.D. Lit.D. Tuxedo
1919 John Moore - - - - - - - - - - - Elmira
1920 Andrew J. Shipman M.A. LL.B. LL.D. - - New York
1916 Walter G. Kellogg - - - - - - - - - Ogdensburg

President of the University and Commissioner of Education

John H. Finley M.A. LL.D.

Assistant Commissioners

Augustus S. Downing M.A. L.H.D. LL.D. *For Higher Education*
Charles F. Wheelock B.S. LL.D. *For Secondary Education*
Thomas E. Finegan M.A. Pd.D. LL.D. *For Elementary Education*

Director of State Library

James I. Wyer, Jr, M.L.S.

Director of Science and State Museum

John M. Clarke Ph.D. D.Sc. LL.D.

Chiefs of Divisions

Administration, George M. Wiley M.A.
Attendance, James D. Sullivan
Educational Extension, William R. Watson B.S.
Examinations, Harlan H. Horner B.A.
History, James A. Holden B.A.
Inspections, Frank H. Wood M.A.
Law, Frank B. Gilbert B.A.
Library School, Frank K. Walter M.A. M.L.S.
Public Records, Thomas C. Quinn
School Libraries, Sherman Williams Pd.D.
Statistics, Hiram C. Case
Visual Instruction, Alfred W. Abrams Ph.B.
Vocational Schools, Arthur D. Dean D.Sc.

Digitized by Google

New York State Education Department

Science Division, March 12, 1913

Hon. Andrew S. Draper LL.D.

Commissioner of Education

SIR: I have the honor to transmit herewith a manuscript entitled *Geology of the North Creek Quadrangle, Warren County, New York,* which has been prepared by Dr William J. Miller, a member of the temporary staff of this Division. Accompanyiing the manuscript are the necessary maps for its adequate illustration.

I recommend the publication of this manuscript as a bulletin of the State Museum.

Very respectfully

JOHN M. CLARKE

Director

STATE OF NEW YORK

EDUCATION DEPARTMENT

COMMISSIONER'S ROOM

Approved for publication this 18th day of March 1913

Commissioner of Education

Digitized by Google

Digitized by Google

University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the Act of August 24, 1912

Published fortnightly

No. 561 ALBANY, N. Y. FEBRUARY 15, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 170

GEOLOGY OF THE NORTH CREEK QUADRANGLE, WARREN COUNTY, NEW YORK

BY

WILLIAM J. MILLER

INTRODUCTION

The North Creek quadrangle comprises an area of approximately 215 square miles in the southeastern Adirondacks. The map[1] covers one-sixteenth of a square degree which lies wholly within Warren county. A branch of the Delaware and Hudson Railroad from Saratoga Springs passes through the region from southeast to northwest, with a terminus at North Creek village. This railroad is an important entry into the southeastern Adirondacks, especially for summer tourists.

The principal villages of the quadrangle are North Creek, Horicon, Pottersville, Chestertown, Wevertown, and Johnsburg with Warrensburg very close to the southeastern corner. Considered as a region so distinctly within the Adirondack Precambric rock area, it is unusually thickly settled and well supplied with roads, which have been a great help in making a detailed study of the complicated geologic features of the quadrangle. Agriculture is the principal industry, though during the summer months a large number of visitors come to the numerous hotels and summer boarding places, especially those in the larger villages and around the lakes. This region, like the Adirondacks in general, was formerly heavily forested but the first growth timber has largely been cut off so that the lumbering industry is now nothing like that of earlier years.

[1] See map in pocket of back cover of this bulletin.

Digitized by Google

GENERAL TOPOGRAPHY AND GEOLOGY

As compared with the general Adirondack area, the North Creek quadrangle presents a rather unique assemblage of topographic forms. Long, prominent mountain ridges, usually with northeast-southwest trend, which are so common in the eastern Adirondacks, are practically absent from the quadrangle, and instead the dominant topography form is the separate, rounded mountain mass or dome which stands out conspicuously above the surrounding country. Such domes, which are numerous and widespread especially in the southern two-thirds of the region, are commonly from 500 to 800 feet high. The highest and largest of these domes is Crane mountain which rises 2000 feet above the immediately surrounding country. Among the other more notable examples are Hackensack,[1] Moon, Potter, No. 9, Little, Huckleberry, Kelm, Chase, Prospect, Mill, and Stockton mountains. These domes always form striking features of the landscape. Ridges do occur but they are seldom more than two or three miles long and do not assume their usual importance in Adirondack topography. This peculiar North Creek topography has largely been produced by a very irregular system of numerous faults in combination with a rather widespread though "patchy" distribution of comparatively weak Grenville strata. In the succeeding pages these matters are described in detail. The maximum range in elevation is from about 640 feet, where the Hudson river leaves the quadrangle, to 3254 feet at the summit of Crane mountain. Many of the mountain tops show altitudes ranging from 1200 to 2000 feet.

The Hudson river, which is the largest stream in the southeastern Adirondacks, passes through the midst of the quadrangle from the northwest to the southeast. The Schroon river, which is one of the chief tributaries of the upper Hudson, cuts across the northeastern portion of the area and thence along the western side of the adjoining Bolton sheet to reenter the North Creek sheet at the extreme southeastern corner near Warrensburg. It is worthy of note that the Schroon river, in the northern portion of the area, flows at a level 200 feet below that of the Hudson to which it is tributary. All the drainage of the quadrangle passes into the Hudson, though that of fully two-thirds of the region does so by first entering the Schroon river. Within the map limits, scarcely a stream of any consequence enters the Hudson from the east, while several streams of considerable size, such as Patterson brook, Glen brook, and Mill creek, enter it from the west.

[1] On the map the name of this mountain is misspelled.

Digitized by Google

Quite typical Adirondack lakes and ponds are fairly abundant, about thirty of them being represented on the map. The largest is Schroon lake, only the southern end of which lies within the map limits. The others range in size from small ponds to lakes two or three miles long such as Friends and Loon lakes.

From the geologic standpoint, the North Creek quadrangle is of more than the usual interest because of both the rock types and structures. With the single exception of the anorthosite, all the important rock formations of the eastern Adirondacks are abundantly represented. Except for the superficial glacial and recent deposits, the rocks of the quadrangle are all of Precambric age, and nearly all are highly metamorphosed, foliated, and folded.

Following is a list of all the rock formations, except the Pleistocene, given in the regular geological order of relative ages:

5 Diabase: wholly nonmetamorphosed, occurring in comparatively small, narrow dikes, and clearly cutting all the other rocks of the region.

4 Pegmatite: wholly nonmetamorphosed, dikelike masses cutting all rocks except the diabase.

3 Gabbro: more or less metamorphosed, occurring in stocks or dikes and cutting all types of the syenite-granite and Grenville series.

2 Syenite-granite group: distinctly gneissoid rocks, representing several facies of a single great intrusive mass, and clearly younger than the Grenville.

1 Grenville series: highly metamorphosed and foliated sedimentary rocks, including crystalline limestone, quartzite, and various dark to light colored gneisses. These are the oldest rocks of the region.

In spite of the rugged character of the topography, the accessibility of all parts of the quadrangle and the general excellence of rock exposures have afforded an unusual opportunity for detailed field work. Many important geologic relationships are very clearly exhibited.

Following are the principal papers which have a more or less direct bearing upon the geology of the quadrangle:

1842 Emmons. Geology of the Second District, N. Y.

1897 Kemp & Newland. Preliminary Report on the Geology of Washington, Warren and Parts of Essex and Hamilton Counties. In 17th Annual Rep't N. Y. State Geologist.

Digitized by Google

1898 Kemp, Newland & Hill. Preliminary Report on the Geology of Hamilton, Warren, and Washington Counties. In 18th Annual Rep't N. Y State Geologist.

1899 Kemp & Hill. Preliminary Report on the Pre-Cambrian Formations in Parts of Warren, Saratoga, Fulton, and Montgomery Counties. In 19th Annual Rep't N. Y. State Geologist.

1911 Miller, W. J. Exfoliation Domes in Warren County, N. Y. In N. Y State Mus. Bul. 149, p. 187–94.

1911 Miller, W. J. Pre-Glacial Course of the Upper Hudson River. In Bul. Geol. Soc. Amer., 22: 177–86.

ROCKS OF THE REGION

GRENVILLE SERIES

General statements. The Grenville series comprises the oldest known rocks of the area. They consist of a great mass of highly metamorphosed and crystallized sediments such as original lime stones, sandstones, and shales which have been changed to crystal line limestone or marble, quartzite, and various gneisses. Since it has not yet been definitely determined whether these rocks should be classed as Archeozoic or Proterozoic in age, the noncommittal term " Precambric " is employed. The weight of evidence is on the side of their Archeozoic age and it is certain that they can not be of late Proterozoic age.

Among the proofs for the sedimentary origin of these rocks within the quadrangle are: (1) the very character of much of the material such as limestone and quartzite which can not possibly have been of igneous origin; (2) the arrangement of the rocks in distinct beds of widely different composition and often sharply alternating; and (3) the common occurrence of graphite (crystallized carbon) as flakes scattered through much of the rock, such graphite being almost certainly of organic origin.

Grenville strata are known to be of common occurrence through out the Adirondack mountain region and this, together with the facts that the total thickness of these strata is very great and that they extend over not only the Adirondack area but also a vast extent of Canada, make it certain that those very ancient strata are of marine origin. It is evident that the Grenville sediments were laid down upon an ocean floor of even greater age but, in spite of twenty years of painstaking field work by several investigators, no trace of that ancient floor has certainly been recognized. Nor has any trace of that very ancient land, whose wearing down by erosion furnished the Grenville sediments, been found. It seems probable that those

Digitized by Google

Pregrenville masses were either engulfed by the later great intrusions or that they were changed beyond recognition.

Areal distribution of the Grenville. About four-ninths of the surface rock of the quadrangle is Grenville, provided we include the Grenville which makes up considerable portions of the areas of mixed gneisses. It should be noted that the Grenville here assumes much more prominence than is usually the case in the Adirondacks. Also, as the accompanying map shows, the Grenville is very widespread in its distribution, it being least prominently developed in the central and northern portions. A striking feature is the "patchy" character of its distribution, this being due to the very irregular manner in which the great igneous intrusions broke through and cut to pieces the Grenville strata.

The three types of Grenville which are sufficiently different to allow of separate representation on the geologic map are:

1 Crystalline limestone which is generally associated with dark hornblende gneiss, this latter rock often being garnetiferous.
2 Quartzite in thin to thick beds and usually more or less interbedded with thin layers of biotite gneiss or sometimes a little limestone.
3 Other gneisses, chiefly gray feldspar-garnet or dark gray biotite-garnet-feldspar or white feldspar-gneiss. Occasionally a little limestone, quartzite, or hornblende-gneiss may occur closely associated, especially where the glacial drift is heavy.

The largest area of Grenville occupies the western portion of the quadrangle and by far the greater part of it consists of limestone and its associated hornblende gneisses. A considerable area of quartzite lies south of Sodom and a smaller one east of Little mountain. The only distinct area of mica-feldspar gneiss covers a few square miles south of Thurman.

Toward the southeast occur two irregular shaped areas of Grenville which are almost entirely made up of limestone and associated hornblende-garnet gneiss, the limestone being especially thick and well shown in outcrops just west of the Potter-Birch mountain ridge.

The large and very irregular shaped area along the eastern side of the sheet consists mostly of various gneisses with one considerable area of quartzite south of Pottersville and another east of Chase mountain. The only mappable limestone belt there is a small one extending eastward from Valentine pond.

Digitized by Google

A patch of Grenville gneiss lies at the extreme northwestern corner of the sheet and another at the northeastern corner, while a belt of limestone just enters the northern map limit at the Natural Bridge. The Grenville around Loon lake consists mostly of white to gray gneisses.

A number of small patches of Grenville are shown within the igneous rock areas and these usually represent actual inclusions of the Grenville which are large enough to be indicated on the map. No attempt has been made to show the many smaller inclusions. The Grenville occurring within the areas of mixed gneisses will be discussed in connection with those gneisses.

Grenville types. The Grenville types are described in considerable detail because, in the writer's opinion, if the broader structural and stratigraphic relations of the Grenville series are ever to be worked out, it is necessary to have these rocks carefully described and mapped over a much larger area than that of a single quadrangle. When a number of the other quadrangles of the southeastern Adirondacks, in addition to those of Broadalbin, Saratoga, and North Creek already published and the Lake Pleasant now being studied, are mapped in detail, it is quite possible that some of the larger structural and stratigraphic features may be made out.

Crystalline limestone. In common with the Newcomb and the southern portion of the Schroon lake sheets, the limestone of the North Creek sheet is much more prominently developed than is usual in the southeastern Adirondacks. The numerous outcrops of limestone (actually observed) are indicated on the accompanying map.

Perhaps the most abundant variety is a nearly white, medium to coarse crystalline, very calcitic limestone through which are scattered numerous flakes of graphite and phlogopite or biotite and occasional specks of pyrrhotite. The calcite crystals range from a few millimeters to more than a half inch across, while the graphite flakes are commonly several millimeters across. Other crystals less often seen in this rock are pyrite, nearly colorless pyroxene, and brown tourmaline. Rarely the limestone is rather dolomitic. This variety of limestone appears in many excellent exposures, the most extensive outcrops perhaps being on the small hill just south of Daggett pond.

A second very common variety is nearly white, medium to coarse-grained calcitic and with numerous irregular shaped, pellucid quartz grains, flakes of graphite, and specks of pyrite or

Digitized by Google

Plate 1

Courtesy Moore & Gibson Co., New York

View of the Natural Bridge on Trout brook, 2 miles northwest of Pottersville. During the season of low water all the water flows under the arch here shown. The rock is banded, Grenville, crystalline limestone.

Digitized by Google

Digitized by Google

pyrrhotite scattered through the mass. The quartz grains usually range in size up to five or six millimeters and stand out as pale straw yellow or clear masses in very bold relief upon the weathered surfaces. Tiny garnet and green pyroxene crystals are rarely present. This variety is also widely distributed and among many other good outcrops are: just east of North Creek; at the Natural Bridge; just south of Crane mountain; and 1½ miles due north of Warrensburg.

A third variety which is rather widely distributed though not so common as those above described may be called serpentine limestone or green marble. One kind of this rock is medium-grained, nearly white, crystalline limestone but with many large blotches or irregular streaks of dark to light olive green serpentine scattered through it. A second kind has scattered through it numerous specks of serpentine or small pale green serpentinized pyroxenes. Different names have been applied to this green marble which has been briefly described by G. P. Merrill who says[1]: "The serpentine in the Warren county Ophiolite, Ophicalcite or Verdantique as it has been variously called, is an alteration or metasomatic product after a mineral of the pyroxene group. The original rock would appear to have been simply a pyroxenic limestone, the pyroxene occurring either in scattering granules or in granular aggregates of considerable size." Among other places this green marble is well shown in the quarries one-half of a mile southwest and three-fourths of a mile southeast of Thurman village, and in the prospect hole at the western base of Hackensack mountain.

Pure white tremolite crystals are sometimes closely associated with the limestone as in many outcrops about a mile east of Little mountain pond. One and one-half miles due north of Warrensburg irregular streaks or veins of tremolite, quartz, pyroxene, and titanite are closely involved with the limestone. The tremolite crystals are up to two inches long and the green pyroxenes up to one-quarter of an inch and perfectly formed.

Asbestos veins sometimes occur in the serpentine marble, these being best shown at the asbestos mine three-quarters of a mile southeast of Thurman where numerous veins attain a width up to three-quarters of an inch.

Green pyroxene or rusty biotite gneisses are sometimes involved in the contorted limestone in the form of streaks or inclusions which have been drawn out or broken by the pressure. See figure 9 and plate 12.

[1] Amer. Jour. Sci., Mar. 1889, p. 191.

Digitized by Google

A hand specimen, from the prospect hole 2½ miles south of Pottersville, is a very coarse-grained mass of calcite, brown hornblende, and graphite through which are scattered small flakes or crystals of phlogopite, pyrite, and pyroxene (mostly serpentinized). The hornblende and calcite crystals are as much as an inch across.

Quartzite. In the quartzite areas shown on the map south of Sodom, south of Pottersville, and east of Chase mountain, the rock consists almost wholly of distinctly bedded, pure quartzite (with layers up to 1½ feet thick) interstratified with thin layers of biotite-quartz gneiss.

The quartzite of the area southwest of Thurman contains many closely involved tremolite and limestone beds.

Thin layers of quartzite are occasionally present in the other Grenville areas but these are usually rather impure containing more or less feldspar, biotite, muscovite or graphite.

Hornblende-garnet-feldspar gneisses. Of the two principal facies of these gneisses, one is a gray, medium to fairly coarse-grained hornblende-feldspar gneiss in which are embedded occasional large brownish red garnets of the almandite type. The feldspars comprise both orthoclase and plagioclase and the hornblende is very dark green to nearly black. Biotite, magnetite, and pyrite generally occur in small amounts. The garnets never show crystal form but are always more or less rounded and highly fractured. These garnets commonly range in size from one to five inches and are often surrounded by rims or envelops of pure hornblende crystals. Fine specimens of such garnets, surrounded by rims of hornblende and embedded in the gray matrix, may be obtained at the old garnet mines near the top of Oven mountain and south of Holcombville.

Another facies is fine to medium-grained, darker gray (with reddish tinge), less feldspathic, and more garnetiferous but with the reddish brown garnets all very small and rather evenly scattered through the rock. Small amounts of magnetite, quartz, and pyrite are also usually present.

These hornblende-garnet-feldspar gneisses are almost invariably closely associated with the limestone beds, the two rocks often appearing in a single outcrop. Numerous fine exposures may be seen along the south and west sides of Crane mountain, 1 mile west of Pine mountain, just northwest of No. 9 mountain, and 1 mile east of Cherry ridge.

Digitized by Google

Plate 2

W. J. Miller, photo

Grenville light gray, very quartzose gneiss, as seen in the quarry near the southeastern end of Loon lake. The banded and jointed character of the rock is well shown.

Digitized by Google

Digitized by Google

Feldspar-biotite-garnet gneisses There are a number of rather distinct facies of these gneisses which show all sorts of gradations from one to another. One common facies is a fine to medium-grained gneiss in dark gray and nearly white alternating bands. The biotite is wholly confined to the dark layers, while small scattering garnets appear in both. Such rock is common in the gneiss areas, being especially abundant on the mountain side east and south of Valentine pond and northeast of Fuller pond.

Another facies is medium to coarse-grained and not so perfectly banded. It is best shown in the small mountain 1½ miles north of Valentine pond.

A third facies is a fine to rather coarse-grained, gray to dark gray rock, clearly gneissoid, usually banded and with numerous pink to amethyst garnets up to five millimeters across. Such rocks are very common in the Grenville gneiss areas as, for example, in the quarry near the southeastern end of Loon lake and at the western base of Prospect mountain.

Hornblende-feldspar gneiss. The most common facies of these rocks is a fine to medium-grained, dark gray gneiss almost wholly devoid of garnets. It is very gneissoid and amphibolite-like but not at all banded. It is closely associated with limestone, sometimes with thin layers of that rock interbedded. The whole ridge extending for five miles southeastward from North Creek is practically made up of this rock.

Another but similar looking gneiss contains orthoclase, plagioclase, hornblende, and hypersthene together with small amounts of magnetite and graphite. This is a much more locally developed gneiss as, for example, immediately under the limestone at the Natural Bridge.

Feldspar-quartz gneisses. These are the white or very light gray gneisses of the district. Perhaps the most typical examples are found in excellent exposures along the road near the quarry at the southeastern end of Loon lake. This is a fine to medium grained, very light gray gneiss with some tiny biotite flakes and small brown garnets scattered through the mass. A slide shows about 80 per cent of orthoclase, microcline, and microperthite in nearly equal amounts; 13 per cent quartz; together with small amounts of plagioclase, biotite and garnet. This light gneiss is in thin to thick beds and repeatedly interbedded with biotite-garnet gneisses. A very similar light gneiss, but with graphite flakes, occurs a mile farther northward along the same road.

Digitized by Google

Feldspar-quartz light gneisses also occur three-quarters of a mile south of Thurman; at Starbuckville; and one-quarter of a mile north of Chestertown.

Pyroxene gneisses. These gneisses are much less abundant than those above described. The most common facies is a fine to medium-grained intimate mixture of small grains or crystals of green pyroxene and reddish brown garnet, with sometimes one and sometimes the other predominating. Such rocks are well exposed in the Sanders Brothers mine near the mouth of Mill creek, and at the old Parker mine just southwest of Daggett pond.

Another facies is a greenish gray to greenish gneiss which contains more or less feldspar in addition to the small garnets. Such rock makes up the inclusion 1 mile west of The Glen, and also occurs along the road one-quarter of a mile north of the north end of Loon lake. Interbedded with the rock at this last named locality is a schistose orthoclase, green pyroxene, phlogopite rock, with occasional graphite flakes up to 3 or 4 millimeters across.

Sillimanite-feldspar-garnet gneisses. Such rocks were observed at but two localities, namely, three-quarters of a mile west-northwest of Starbuckville and 1 mile south of South Horicon. A thin section and specimen from the large outcrop at the latter place shows the rock to be fairly coarse-grained, gray, moderately gneissoid and made up of a matrix of orthoclase, microperthite, and quartz in which are embedded many pale pink garnets, small prisms of sillimanite, tiny graphite flakes, and some small magnetite and colorless pyroxene crystals. At the first named locality the rock is well banded and contains fibrous sillimanite in irregular streaks and also some biotite.

Graphite schists or gneisses. As we have learned, graphite flakes are common in the limestone and sometimes present in the quartzites and various gneisses. True graphite schists or gneisses are, however, rare, the only ones noted being at the old graphite mine 1 mile southwest of Johnsburg where the rocks are light to dark gray and thin to thick bedded. One specimen is almost a quartzite, but with numerous small biotite and graphite flakes. Another specimen is a feldspar-quartz schistose rock without biotite and fairly filled with graphite flakes generally from 1 to 2 millimeters across. Still another specimen is a feldspar-quartz-biotite gneiss with few graphite flakes.

Grenville stratigraphy. Any attempt to work out the stratigraphy of the Grenville series must of necessity be much more

Digitized by Google

unsatisfactory than if we were dealing with a great thickness of unaltered fossiliferous strata. However, because of the excellence and frequency of the exposures in most of the Grenville areas, some unusually good results have been obtained though it should not be understood that the statements or conclusions here given are always regarded as thoroughly established. Much detailed work on the adjoining areas will have to be carried on before such statements can possibly be made.

So far as can be made out from a study of all the Grenville sections, the order of succession of the strata appears to be:

5 Dark gray biotite-garnet gneiss. Thickness unknown.
4 Dark hornblende gneiss. Thickness at least 2000 feet.
3 Crystalline limestone. Thickness of some 10,000 or 12,000 feet, but frequently interbedded with more or less hornblende or pyroxene gneisses or quartzite.
2 Quartzite. Thickness of about 3000 feet and generally pure except for very thin layers of biotite gneiss.
1 Gray, banded biotite-garnet gneiss. Thickness unknown.

Some Grenville rocks which are more locally well developed are not included in the above list because their stratigraphic positions are wholly unknown. Among such rocks are the graphite schist, the white gneiss, and the sillimanite gneiss.

The best extensive section within the quadrangle is shown by figure 1 which represents the succession of strata along a northeast-southwest line through the Grenville area between Oven mountain and Wevertown. The position of the section is indicated by the line EE on the geologic map. This is by no means a perfectly continuous section, but the outcrops are numerous enough so that the condition of things shown in the figure can not be far wrong. A total of from 18,000 to 20,000 feet of Grenville strata appears to be shown in this section. The dip and strike of the strata are pretty constant the whole length of the section, and though the Oven mountain fault probably passes across the section it is not thought materially to affect the position and thickness of the strata. The hornblende gneiss toward the top of the section forms the prominent ridge which extends northward to the Hudson river.

Figure 2 represents an east-west section across the valley one-third of a mile south of Daggett pond where there is an almost unbroken succession of nearly pure limestone whose total thickness is something like 3000 feet. On the west side, and dipping under the limestone, are some beds of hornblende-garnet gneiss.

Digitized by Google

This limestone appears to correspond with the lower part of the limestone mass in figure 1.

There is no positive proof that the quartizite shown in figure 3 is the same as that of the lower part of figure 1, but the two rock masses are of much the same character and both are of great thickness. This quartzite of figure 3, which represents a section across the valley between Chase and Bull Rock mountains, is nearly pure and shows a thickness of about 3000 feet with banded biotite-garnet gneiss dipping under it on the west side.

Figure 4 is another fine section of the quartzite which also shows the underlying rock to be a banded biotite-garnet gneiss of unknown thickness.

The limestone of the Valentine pond valley appears to dip southward under a thick belt of distinctly light and dark banded garnet gneisses, but just where these rocks belong in the columnar section can not be said.

The quartzite in the area southwest of Thurman is often very tremolitic, which suggests that it does not belong with the other quartzites of the quadrangle.

QUARTZ SYENITE

As shown on the geologic map, the syenite covers about two-ninths of the area of the quadrangle and is distributed in very irregular shaped areas. Boundary lines between the syenite and granite can not be sharply drawn because of the gradation of the one rock into the other. Against the Grenville the boundary is generally not very sharp except where the Grenville has been faulted against the syenite.

As regards granularity, structure and mineral composition the syenite is a very variable rock. The granularity ranges from fine to fairly coarse grain, with medium grain decidedly prevalent and with only rarely suggestions of a porphyritic texture. Evidence of crushing or granulation of the rock is common, especially in the cases of the more acid (granitic) syenites where the feldspars more than the other minerals are granulated. In structure the rock ranges from only faintly gneissoid to very clearly gneissoid, which is due to the arrangement of the dark colored minerals with axes parallel to the direction of foliation. All facies of the syenite are quartzose and the range in mineral composition is from pyroxene-quartz-syenite to granitic hornblende syenite as shown in table 1.[1]

[1] In this and the succeeding tables only close approximation to the volumetric proportions of minerals present is intended.

Digitized by Google

Titanite

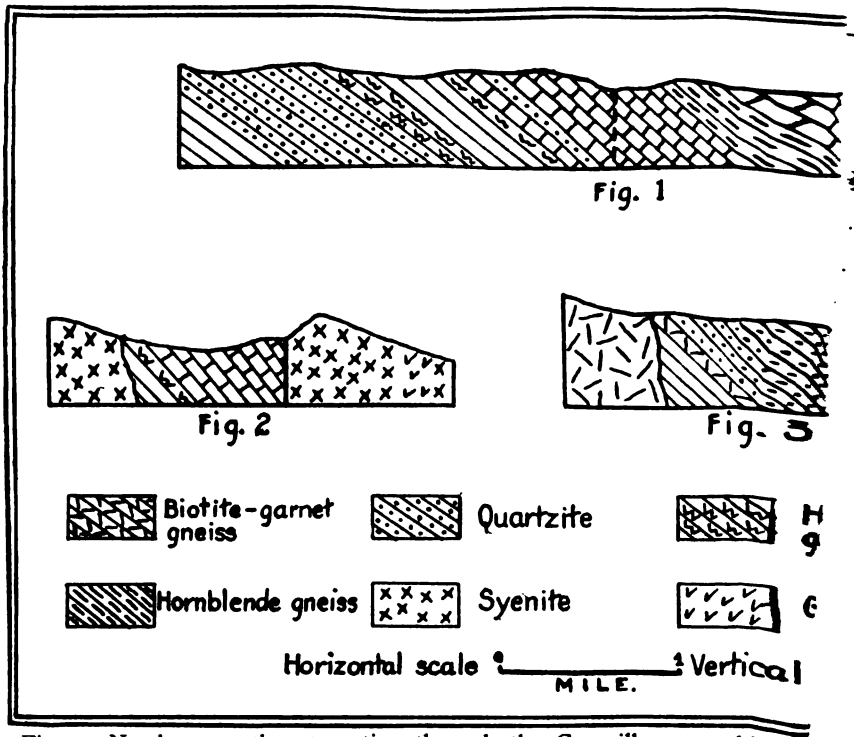


Fig. 1. Northeast-southwest section through the Grenville area which position of the section is indicated on the geological map

Fig. 2. Section along an east-west line through the Grenville one-thi

Fig. 3. Northeast-southwest section from the summit of the southern Chase mountain and through the belt of Grenville quartzite

Fig. 4. Northeast-southwest section through the summit of Loon Lak

Digitized by Google

Digitized by Google

TABLE I

Pyroxene syenite

	No. of slide	Orthoclase	Microperthite	Microcline	Plagioclase	Quartz	Hornblende	Biotite	Monoclinic pyroxene	Magnetite	Zoisite	Apatite	Zircon	Pyrite	Titanite
1	17	25	....	....	Ol-Lab 55 Ol	12	....	5	25	2	½	¼	¼	.....	..
2	13	15	25	15	14 Ol	18	1	....	10	1	½	¼	¼	.....	..
3	14	25	25	....	5	20	8	....	15	1	½	¼	¼	little	..

Granitic hornblende syenite

4	15	25	25	....	Ol 6 Ol	22	18	2	....	1	½	¼	¼	.....	..
5	34	5	50	....	5 Ol	24	12	....	....	2	1	¼	¼	.....	½
6	12	10	35	2	12 Ol	25	14	....	....	1	½	little	½	.....	..
7	16	5	65	....	3	25	½	½	....	½	½	.....	little	.....	..

The color of the fresh rock is the usual greenish gray of the Adirondack syenites, while the weathered surfaces are of yellowish brown to brown color. Because of vigorous glaciation even the weathered surfaces are hard, decomposed rock seldom being seen except in a few protected places on the south sides of mountains. Below this weathered surface it is usually not more than a few inches to the fresh greenish gray rock.

That the syenite has been intruded into the Grenville is abundantly proved by the many inclusions of all sorts of Grenville rocks, but most of these are too small to be represented on the geologic map. Some of the best examples of Grenville inclusions are to be found in the mixed gneiss areas which will be described below.

Pyroxene syenite. This syenite represents the most basic facies of the great syenite-granite intrusive mass. The generally faint development of gneissoid structure, low quartz and hornblende contents, and the presence of pyroxene are the chief differences between this and the granitic hornblende syenite. The range in composition is well brought out in table I which represents thin sections of carefully selected samples. The pyroxene is seen to be the most characteristic mineral of the rock. This pyroxene is of a beautiful green color, clearly monoclinic, and shows good cleavages.

Digitized by Google

Crystal outlines are sometimes distinct. Professor Kemp has noted a similar pyroxene in the syenite of the Elizabethtown-Port Henry quadrangles and he suggests the presence of the jadeite molecule in its composition. Garnets seldom occur in this syenite.

The most basic rock of all is shown by no. 1 of the table. This rock makes up the Bull Rock mountain mass. It is unusually high in plagioclase, pyroxene, and biotite and low in quartz, and is nearer the gabbro in appearance and composition than any other rock of the whole region. It is fine to medium grained and of rather a bluish gray than greenish gray color when fresh.

Numbers 2 and 3 of the table are from the mountain 2 miles south-southeast of Riverside, and from along the road 1 mile west-southwest of Daggett pond respectively. In the field it is generally impossible to distinguish this pyroxene syenite from much of the granitic hornblende syenite and this, together with the fact that the two rocks grade perfectly into each other, renders separate mapping practically impossible. The pyroxene syenite, however, is certainly less common than the hornblende syenite.

Granitic hornblende syenite. The range in mineral composition of this rock is shown by the selected examples given in table 1. Microperthite and orthoclase are always present though in very variable amounts, while the quartz and hornblende contents are high and biotite is scarcely represented. In addition to the minerals shown in the table a few scattering garnets sometimes occur. No. 7, with its almost total lack of hornblende, is an unusual type. The gneissic structure is usually well developed though at times it becomes very faint. This granitic syenite on the one hand grades perfectly into the pyroxene syenite and on the other into the granites below described. Arbitrarily, when the quartz content passes beyond 25 per cent, the rock is classed as granite and, as nearly as possible, the rocks have been separately mapped on this basis. The very common presence of biotite in the granite has also been a help in mapping.

Numbers 4, 5, 6, and 7 are respectively from Potter mountain, 1½ miles east of Pottersville, one-third of a mile north of the north end of Loon lake, and the summit of Little mountain.

GRANITE

As already stated, the granitic syenite passes through perfect gradations into the granite and these rocks are very clearly only different phases of the same great intrusive body. The rock is rather arbitrarily called granite when it contains more than 25

Digitized by Google

per cent of quartz. By becoming coarse-grained and porphyritic it also passes gradually into the granite porphyry. As in the case of the syenite, the contact against the Grenville is seldom sharp except along the lines of faulting. The area covered by the granite is almost the same as that of the syenite or about two-ninths of the quadrangle.

This rock, too, is decidedly variable as regards color, granularity, structure and mineral composition. The colors range through greenish gray, light gray, and pinkish to almost red. These color varieties are especially well shown in the vicinity of The Glen. Pinkish granites are the most abundant.

The granularity of the rocks varies from fine to coarse grain, with a medium grain predominating. Coarse-grained types often show a tendency toward porphyritic texture and thus approach the granite porphyry. The granites are almost always highly granulated, especially the more gneissoid varieties in which the feldspars are most badly crushed. There is a wide range from poorly gneissoid rocks to those which are highly foliated and almost banded, the latter being particularly true of the commonly occurring pink granites.

The range in mineral composition is well illustrated by the selected examples given in table 2. As compared with the granitic syenite, the chief differences are the high quartz content, the common occurrence of microcline, the generally lower content of hornblende, and the almost constant presence of biotite.

TABLE 2

Granite

	No. of slide	Orthoclase	Microperthite	Microcline	Plagioclase	Quartz	Hornblende	Biotite	Zoisite	Garnet	Zircon	Magnetite	Apatite
1	21	22	22	....	Ol 7	26	20	2	.....	.....	little	1	.....
2	35	7	30	18	Ol 3	28	8	1	½	3	½	1	½
3	18	17	50	....	.....	30	....	2	.....	.....	little	1	.....
4	53	10	45	4	Ol-And 5	30	5	....	.....	½	¼	¼	.....
5	32	5	40	....	Ol-And 10	35	7	1	½	....	½	1	little
6	31	10	18	14	Ol 10	35	6	2	1	1	½	2	½

Digitized by Google

Number 1 is a fine example of a transition rock from a granitic syenite to granite as seen along the river in big ledges one-half of a mile south of The Glen. The color of the rock is pinkish gray. Especially noteworthy are the comparatively low quartz and high hornblende contents, and the absence of microcline.

Number 3 is typical looking pink, biotite granite from the granite ridge just west of Crane mountain.

Number 6 is a very quartzose, hornblende, biotite, pink granite with considerable microcline as seen in excellent outcrops along the road 1½ miles south of Riverside.

Only a few of the observed masses of Grenville or mixed gneisses which occur within the granite are large enough to be shown on the geologic map. Small inclusions or stringers, sometimes sharply outlined and sometimes seeming to grade into the granite, are very numerous. Only a few examples will be cited. Thus, a large, homogeneous mass of very typical granite, one-quarter of a mile above the mouth of Glen brook, contains a number of clear-cut Grenville hornblende gneiss inclusions. These inclusions are mostly long (10 to 20 feet), narrow stringers which are drawn out parallel to the foliation of the granite. Similar inclusions are common 1 mile south of The Glen along the east bank of the river, and in the Mill mountain mass. On the west bank of the Hudson river and just opposite the Ferry (east of Heath mountain) a ledge of coarse-grained hornblende granite contains ten or fifteen fine examples of small (none over 3 feet long) very angular inclusions of Grenville hornblende gneiss.

Features of special interest in connection with the granites are the frequent and comparatively sudden transitions from the gray to pink varieties, and from the more syenitic or basic facies to the more truly granitic facies. The effect is to give wide bands or layers of varying color and composition and yet all clearly belonging to the same rock mass because of the true gradation of one layer or band into another. Among many places where such phenomena have been observed are in the vicinity of The Glen, and along the road one-half of a mile north of the north end of Loon lake. The writer has already described similar occurrences in the region of the Port Leyden quadrangle.[1] Professor Kemp, in the bulletin on the Elizabethtown-Port Henry region, has recently described and suggested an explanation for similar but even more extreme phenomena as follows: "The most acidic variety will quite sharply replace it [the syenite]; and in the same way a

[1] N. Y. State Mus. Bul. 135, p. 16–17.

Digitized by Google

very basic variety may come in and constitute the section for 50 or 100 feet or more. Yet, while the transition is sharp, there is no evidence of separate intrusive masses nor is one justified in inferring more than a differentiation of an eruptive mass into layers or portions of contrasted composition. . . . That this differentiation takes place in magmas is one of the growing convictions of students of igneous rocks."[1] Now, so far as the writer's observations in the North Creek region are concerned, they fully accord with Professor Kemp's interpretation of this puzzling phenomenon. Of course, the rocks have been severely compressed and possibly folded and the banded effect may thus have been accentuated, but nevertheless there appears to be no getting away from the apparent fact of some sort of differentiation of the granitic magma into layers of varying composition.

GRANITE PORPHYRY

This rock represents another phase of the great syenite-granite intrusive mass and always shows a perfect gradation into either the granite or syenite, so that sharp lines of separation between these rock types can not be drawn. On the accompanying geologic map this rock is seen to be rather widely distributed in small to large irregular shaped areas making up altogether perhaps a little less than one-ninth of the area of the quadrangle. A very similar rock occurring in the vicinity of Northville has recently been described by the writer[2] and that description applies almost perfectly to the North Creek granite porphyry. Exactly the same evidences which were presented to prove that the Northville granite porphyry is really only a facies or differentiation product of the great syenite magma, may also be applied to this granite porphyry. Still more recently such rock has been found by the writer in the northern portion of the Lake Pleasant quadrangle. Thus it is quite certain that granite porphyry is a rather widespread rock in the southeastern Adirondacks.

The typical rock is gray to pinkish gray, thoroughly gneissoid, and with beautifully developed porphyritic texture. The phenocrysts of feldspar are usually from one-half to one inch long and more or less flattened parallel to the foliation. Carlsbad twins are often easily recognizable. Feldspar, quartz, and biotite or hornblende are always plainly visible to the naked eye. Often large

[1] N. Y. State Mus. Bul. 138, p. 48 and 128.

[2] N. Y. State Mus. Bul. 153, p. 17-20.

Digitized by Google

quartz crystals are also decidedly flattened parallel to the foliation. The phenocrysts are embedded in a fine to medium-grained matrix of feldspar, quartz, and biotite or hornblende. The rock nearly always shows the effects of dynamic metamorphism, the more or less crushed and granulated feldspars generally being clearly visible to the naked eye. The degree of foliation often varies considerably from place to place, and the porphyritic texture, especially along the borders, becomes notably less prominent.

The general range in mineral composition is shown by the examples given in table 3.

TABLE 3

Granite porphyry

	No. of slide	Orthoclase	Microperthite	Microcline	Plagioclase	Quartz	Hornblende	Biotite	Magnetite	Zircon	Zoisite	Apatite	Garnet
1	25	10	10	25	Ol-And 1	44	4	· 4	....	¼	½	¼	1
2	26	10	10	25	Ol-And 5	30	10	....	1	¼	½	¼	8
3	27	15	20	20	.....	30	8	....	1	¼	½	¼	5
4	28	8	35	8	Ol-And 7	30	....	10	1	¼	½	¼	.....

Number 1 is a very typical looking granite porphyry from the quarry at Horicon. This is the rock which Professor Kemp described as the "Horicon gneiss" some years ago.[1]

Number 2 is from Kelm mountain; no. 3 from one mile south of Kelm mountain; and no. 4 from the south base of Prospect mountain.

A good example of a rather coarse, somewhat porphyritic, pink granite which might almost pass for a granite porphyry occurs in the quarry along the road 2 miles northeast of Pottersville.

It so happened that no Grenville masses within the granite porphyry were of sufficient size to be indicated on the geologic map, but in the field one may see a good many small patches or streaks of Grenville gneiss sometimes as clear-cut inclusions and at other times seemingly more or less fused into the granite, thus giving very locally a sort of mixed gneiss effect.

[1] 17th Annual Rep't N. Y. State Geol. 1897, p. 510, 541.

Digitized by Google

MIXED GNEISSES

In the areas mapped as mixed gneisses, the rocks are more or less intimate associations of the various Grenville, syenite, granite, and granite porphyry gneisses. They are really areas of Grenville which have been all cut to pieces, and in some cases apparently partially fused, by the great igneous intrusives. In some areas true Grenville rocks predominate; in others true igneous rocks prevail; while in still others the most common rock appears to be of intermediate character due to an actual melting and incorporation of Grenville sediments by the molten intrusions. Except along fault lines, these mixed rocks everywhere grade into either true Grenville or syenite or granite and the drawing of boundary lines is largely a matter of personal judgment. Any attempt to separate the various members of these mixed gneiss areas would be unsatisfactory because of the general insufficiency of outcrops and the small scale of the map.

There are many places within the quadrangle where, as a result of more or less perfect assimilation, rocks of intermediate composition occur on both small and large scales. One and one-third miles northeast of Kelm mountain and near the map edge there are fine illustrations of dark Grenville garnet gneiss inclusions in the granite porphyry, the inclusions usually grading perfectly through zones of a few feet into the granite. The intermediate rock is coarse-grained, very garnetiferous, and not so porphyritic as the true granite porphyry. Similar cases of local assimilation by granite porphyry, granite and syenite have been observed at other places within the quadrangle.

On a large scale, perhaps the best examples of rocks of intermediate character make up most of the mixed gneiss area just east of Chestertown. Thus the whole top of Prospect mountain consists of gray, fine-grained, very massive rock which has the composition of a biotite granite. This rock is quite homogeneous except for occasional patches or stringers of gray Grenville gneisses which are fused into the mass. Passing southward and southwestward down the mountain side, this rock grades perfectly into a medium-grained, gray, biotite granite which contains very few Grenville inclusions, and this rock, in turn, grades perfectly into the typical biotite granite porphyry at the base of the mountain. Passing westward down the mountain side, however, the fine-grained granitic rock at the top gradually becomes coarser grained and contains more numerous and more clearly defined inclusions

Digitized by Google

of Grenville gneisses, with these rocks, in turn, grading into pure biotite-garnet and quartzitic Grenville gneisses at the base of the mountain. Thus we have a perfect transition from the gray, granitic rock into the granite porphyry, on the one hand, and into the Grenville on the other so that there appears to be no escape from the idea that these gray, granitic rocks were formed by actual fusion and incorporation of more or less of the Grenville into the granite porphyry magma. The presence of the inclusions does not necessarily oppose this view because they may well enough simply represent fragments of Grenville which were caught in the granite magma just before consolidation or when the temperature was not high enough actually to melt the fragments. Gray granitic rocks of apparently the same origin are common throughout this mixed gneiss area.

Another interesting mixed gneiss area is the one just north of the village of Horicon. In the vicinity of the quarry, at the base of the mountain, the rock is very typical granite porphyry which contains a few long, narrow, sharply defined, Grenville gneiss inclusions. Going up the mountain side from the quarry, the granite porphyry, which at times (in patches or wide bands) appears typical, is intimately associated with Grenville. This Grenville occurs as large and small inclusions, often sharply defined and nearly always drawn out parallel to the foliation. The included rocks are chiefly banded biotitic, hornblendic, and quartzitic gneisses often in bands from 20 to 30 feet wide. Toward the top of the mountain the rock is mostly like the gray granitic rock already described as occurring at the top of Prospect mountain, and the inclusions are fewer and not so sharply defined. Here again this granitic gneiss appears to be an assimilation product, while farther down the mountain side the temperature seems not to have been high enough to cause any considerable melting or assimilation of the included gneisses.

In the large, mixed gneiss area south of Henderson mountain there are many fine illustrations of very intimately associated Grenville and gray granitic rocks, the Grenville often having been more or less melted into the granites. The granites predominate and some of them at least are thought to be assimilation products. Such phenomena are well exhibited from Igerna southwestward to the river.

In the mixed gneiss area which borders the Chase-Kelm mountain granite porphyry mass on the west, the prevailing rock is a

Digitized by Google

Plate 3

W. J. Miller, photo

View showing contact between Grenville limestone and granitic syenite as seen from across the Hudson river one-fourth of a mile north of the ferry (southwest of Moon mountain). The smooth ledge at the river's edge on the left and another toward the upper right hand corner are parts of a single mass of syenite mostly concealed by the trees. The other rock is Grenville limestone (white) with numerous closely involved streaks and bands of hornblende (dark) gneiss. The sharp contact between the syenite and Grenville is not well brought out in the picture.

Digitized by Google

Digitized by Google

gray, medium-grained, biotitic, granitic gneiss which is intimately associated with some Grenville gneiss. Here again it is quite certain that the granitic gneiss forms a border zone between the granite porphyry and the Grenville, where the former has more or less assimilated some of the latter.

Along the southeastern base of Moon mountain there are excellent exposures of Grenville much cut up by, and often fused into, syenite.

The mixed gneiss area at the southwestern corner of the map affords many fine examples of syenite or granite and Grenville closely involved and fused together. There are also many well-defined inclusions or stringers of Grenville scattered through the igenous rock. These phenomena are especially well shown on Wolf Pond mountain.

The mixed gneiss area which surrounds Heath mountain consists very largely of Grenville gneisses and limestones through which numerous small masses of syenite or granite have been intruded. The most interesting exposures occur along the river for nearly a mile northward from the Ferry. About 1 mile north of the Ferry and on the east side of the river, are great ledges of Grenville limestone and hornblende gneiss, these rocks being badly contorted and broken and containing some patches of good syenite, 10 to 30 feet across, and completely surrounded by either hornblende gneiss or marble. At the same locality a large mass of syenite overlies crystalline limestone and shows the actual sharp contact for fully 100 feet, there being no particular contact phenomena (see plate 3).

About one-half of a mile north of the Ferry, and along the road, there are several very interesting inclusions of Grenville limestone in the syenite. Two of these inclusions (one being 3 or 4 feet across and the other 20 feet long and 2 to 4 feet wide) are completely surrounded by, and in very sharp contact with, the syenite. The limestone is coarse, crystalline, calcitic, and contains graphite. At the contacts small green pyroxene crystals are often common.

The small area near Daggett pond is of interest because the Grenville is there interbanded with granitic syenite, the bands of each rock often being 20 to 40 feet wide and the contacts pretty sharp. One Grenville band is a garnet, pyroxene gneiss, while others are biotite or hornblende gneisses.

The area of mixed gneisses lying to the east of Stockton and Gage mountains shows numerous exposures of closely associated

Digitized by Google

syenite or granite and Grenville gneisses in about equal amounts. There are few suggestions of assimilation, the igneous and sedimentary rocks generally retaining their characteristic features.

The other mixed gneiss areas require no special mention.

THE GABBRO AND ITS DERIVATIVES

Because of the large number of exposures, mode of occurrence, excellent outcrops, frequent contacts against the country rocks, and the remarkable variations in composition and appearance the gabbros are of unusual interest and will be described in considerable detail.

Mode of occurrence

The gabbro and its derivatives nearly always occur in the form of small stocks or bosses rather than as true dikes, their length ranging from 30 to 40 feet to about a mile, and with widths up to three-fourths of a mile. Sixty-one separate gabbro bodies were found and are shown on the geologic map. In spite of the detailed field work a few others have probably escaped the writer's notice.

The ground plan, as represented on the geologic map, is almost invariably elliptical, though sometimes approaching the circular. When the contact with the country rock is carefully traced out it is commonly found to be sharp and shows smooth or flowing outlines against the country rock. In only two or three cases do the gabbro masses approach the true dikelike form, and in each of these cases fine-grained tongues were found to extend into the surrounding rock. One stock, one and one-third miles southeast of Chestertown, shows several such tongues, one of them (1 to 6 inches wide) clearly cutting the granite porphyry for 30 feet. Other and smaller gabbro dikes at the summit of Hackensack mountain, and 1 mile south of South Horicon show a number of such fine-grained tongues.

At one place in the dike or boss which crosses the road 1¼ miles a little west of south of South Horicon, fairly coarse-grained gabbro is in sharp contact (for 6 or 8 feet) with fine-grained gabbro, the latter becoming coarser grained again away from the contact. This suggests a second intrusion of the gabbro after the first but after the first had cooled.

It is a striking fact that in spite of many excellent contacts which were observed, such dikelike tongues are so rare. As Harker says[1]: "Although most of the bodies of granite and other plutonic rocks

[1] Natural History of Igneous Rocks, 1909. p 86.

Digitized by Google

which have been loosely described as bosses, and so rendered in ideal sections, are doubtless of laccolitic or other stratiform shape; some, not of the largest dimensions, appear to have a pluglike form, with more or less vertical boundaries." The small stocks or bosses of the North Creek region are certainly of this pluglike or pipelike form as shown by the very character of their eroded cross-sections and also by the vertical contacts with the country rock. Among the many fine contacts which came under the writer's observation, not a single exception to the rule of vertical or practically vertical contacts was noted.

In most cases the long axes of the stocks lie parallel to the foliation of the inclosing rock, though there are some notable exceptions. It would therefore seem that the molten intrusives generally followed the lines of least resistance but, even in these cases, the broad ends of the stocks cut sharply across the foliation bands, sometimes for a distance of several hundred yards. Such a phenomenon is well exhibited at the south end of the large stock just south of Mountain Spring lake where a big quarry has been opened up along the contact.

The gabbro stocks are not at all uniformly distributed over the area of the quadrangle, the largest number being confined to a nearly north-south belt with a width of from 3 to 5 miles and extending through the middle of the quadrangle. This belt roughly corresponds to the general strike of the foliation. A secondary belt, about 1 mile wide and 5 miles long near the middle eastern boundary of the sheet, contains a dozen small stocks. With a single small exception the whole western side of the quadrangle is devoid of gabbro masses. In the northeastern portion a few stocks occur, but they may really belong to some other belt not yet mapped. Thus we see that the gabbro intrusions were limited to rather well-defined areas or belts.

Among these gabbro stocks four types of occurrence are especially noteworthy as follows: (1) The normal, dark, basic gabbro with diabasic texture and usually homogeneous throughout; (2) gabbro chiefly of the normal type but with irregular patches or masses of lighter colored rocks of syenitic or dioritic make-up, these patches blending with the normal gabbro; (3) the whole stock made up of lighter colored, more acidic rock; and (4) any one of the above types with blocks or inclusions of the country rock. These four types are all primary variations. Examples of the last three types will be given later.

Digitized by Google

Megascopic features

The gabbro and its derivatives present a truly remarkable number of facies or varieties clearly visible to the naked eye. The coarseness of grain varies from the merest fraction of a millimeter to fully an inch (for example, the stock on the south side of Loon lake). The fine-grained portions are confined to the borders of the stocks or the few branching tongues and were caused by the more rapid chilling of the rock in those positions. Even the finest grained rocks, however, are holocrystalline. As a rule the coarseness of grain increases toward the interior of the masses, though often medium to coarse grained rocks extend to the very contact. The typical or prevailing gabbro shows a medium grain; that is, the grains are from 1 to 5 millimeters across.

The texture varies from coarse to medium to fine-grained granitoid, to medium to coarse-grained diabasic (ophitic). The gabbro from the stock on the south side of Loon lake is an excellent example of diabase texture in which the feldspar laths attain a length of an inch or more. The typical gabbro always exhibits the diabasic texture.

In color, the gabbro and its derivatives range from nearly black through dark to light gray, the darker varieties often showing a slight reddish tinge due to the presence of garnets. The gray rocks all belong to the more acidic (dioritic and syenitic) facies described below. In one case a greenish gray color was noted. The very dark color of the typical gabbro is due to the fact that the feldspars are so charged with tiny black inclusions.

In the typical gabbros the minerals commonly recognizable with the naked eye or hand lens are plagioclase, pyroxene, hornblende, garnet, biotite, and ilmenite, while in addition to these orthoclase and quartz may often be seen in the more acidic phases.

Except for the rather common presence of highly gneissoid to even schistose amphibolite borders, the stocks of typical gabbro are practically devoid of gneissoid structure. Some of the lighter colored, more acidic phases, however, show fairly well-developed foliation.

It is important to note that many of the above described variations may be found within a single stock as, for example, south of Mountain Spring lake. The following statements from Smyth's description of a similar western Adirondack gabbro[1] fittingly apply here: "These [primary] changes in character take place very suddenly, and the different phases are most irregularly distributed,

[1]Amer. Jour. Sci., April 1896, p. 273-74.

Digitized by Google

Plate 4

W. J. Miller, photo

A typical exposure of gabbro as seen three-fourths of a mile south-southwest of Loon Lake mountain. Note the very irregularly jointed character of the rock and the whitish mass of pegmatite cutting the gabbro in the lower left-hand corner.

Digitized by Google

Digitized by Google

seeming to conform to no law. . . . These primary variations in the rock suffice to give considerable diversity to different portions within a limited area, but this diversity is greatly intensified by certain secondary modifications of structure and composition. As a result of the combined effect of primary and secondary variations, it would be easy to collect, within an area of a few square rods, a half dozen or more specimens whose appearance even in thin section would scarcely suggest that they had any connection with one another." Cushing says[1] of the Adirondack gabbros in general that they show much variation, both primary and secondary, from place to place. Both of these investigators proceed to discuss the secondary variations and their causes but, so far as the writer is aware, little or no attention has been given to the causes of the primary variations which will be considered below.

Microscopic features

Mineralogical composition. The following table will serve to show the great range in mineralogical composition of the gabbro and its derivatives. The figures refer to percentages by volume and are meant to be close approximations only.

TABLE 4

Mineralogical composition of the gabbro and its derivatives

	Slide No.	Orthoclase	Plagioclase	Hornblende	Hypersthene	Augite	Diallage	Ilmenite	Pyrite	Biotite	Garnet	Quartz	Zoisite	Zircon	Apatite	Olivine	Titanite
1	45	...	Lab.$_{50}$	...	15	...	...	3	.....	9	8	....	....	.....	.....	15	.....
2	6	...	Lab.$_{50}$	8	17	...	7	1	little	8	8	....	....	.....	.....	....	.....
3	2	4.5	Ol-Lab. 38	27	12.5	3	...	2.5	1	7	3.5	....	....	.....	little	....	.....
4	46	15	Lab. 30	10	15	...	...	5	.....	5	20	....	....	.....	.....	....	.....
5	42	10	Ol-Lab. 40	25	....	...	23	little	little	1	little	....	....	.....	.....	....	.....
6	47	10	Ol-Lab. 30	25	20	...	10	1	.....	2	2	....	....	.....	.....	....	.....
7	1	5	Ol-Lab. 40	16	25	...	...	1	.....	5	8	....	....	.....	.....	....	.....
8	60	20	Ol-Lab. 40	10	14	...	...	1	1	2	10	1	1	.....	.....	....	.....
9	5	5	Ol-Lab. 45	14	20	...	...	2	1	6	2	....	....	.....	.....	....	.....
10	49	32	Ol-Lab. 10	45	....	...	...	2	little	6	5	....	....	little	.....	....	.....
11	3	32	Ol-And 20	25	....	...	...	5	.....	5	.....	10	1	....	little	....	little
12	4	15	Ol-Lab. 57	15	....	...	...	2	1	10	.....	....	....	little	.....	....	.....
13	44	50	Ol-Lab. 15	20	....	8	2	little	little	...	1	2	....	little	little	....	.....
14	43	45	Ol-And 15	28	....	2	...	1	little	...	.....	8	....	.....	little	....	.....

Perhaps the most striking feature brought out by this table is the range of rock types, through many intermediate phases, from a very basic olivine norite to quartz-hornblende syenite. Thus, no. 1 is an olivine norite; nos. 2, 3, 4, 6, 7, and 9 are hornblende norites;

[1] N. Y. State Mus. Bul. 95, p. 328.

Digitized by Google

no. 5 is a hornblende gabbro; no. 8 is a gabbro-diorite; nos. 10, 13, and 14 are hornblende syenites; no. 11 is a monzonite; and no. 12 is a diorite. The large number of minerals — sixteen in all — is also notable. It is also important to note that in the above table, nos. 3 and 4, 7 and 8, 9 and 10, and 11 and 12, respectively, come from single stocks.

The predominating mineral is feldspar which ranges from labradorite alone in some rocks through all stages, to those rocks which are rich in the more acid plagioclases or orthoclase.

Hornblende, generally in considerable amount, occurs in all but one (no. 1) of the rocks. Sometimes it makes up a fourth or more of the whole rock. Much of the hornblende in the more basic rocks, at least, is of secondary origin and forms corrosion rims (below described) around other minerals. Its color varies from green to brown. In one slide many examples of the transition from pyroxene to hornblende are perfectly shown.

Hypersthene, with a single exception (no. 5), is an important constituent of all the more basic types. It is almost always highly granulated and with pleochroism from greenish gray to pale reddish brown.

Augite and diallage of greenish gray color and with good cleavage, are only occasionally present and rarely as important constituents.

Ilmenite is invariably present in amounts up to 5 per cent and often with transition to leucoxene.

Pyrite in small amount seldom fails.

Biotite and garnet of the usual sort, though mostly in tiny flakes or grains, are present in moderate quantity in all but certain of the more acidic facies. The unusually high percentage of garnet in no. 4 is a fine-grained border phase of a stock.

Quartz, in small irregular shaped grains, is wholly confined to the acidic types.

Zoisite, in small stout prisms, sometimes makes up about 1 per cent of the rock.

Zircon and apatite, in very small quantities, are almost wholly confined to the acidic facies. The usual absence of the apatite from the typical gabbros is especially noteworthy.

Olivine was noted in but one case (no. 1) and this in the only rock from which hornblende is missing.

Titanite in a few small grains was noted in no. 11.

Reaction or corrosion rims. Reaction or corrosion rims, which are well known in many basic rocks, are exhibited in a truly re-

Digitized by Google

Plate 5

W. J. Miller, photo

Photomicrographs of thin sections of gabbro from the stock on the south side of Loon lake. Each magnified 15 diameters.

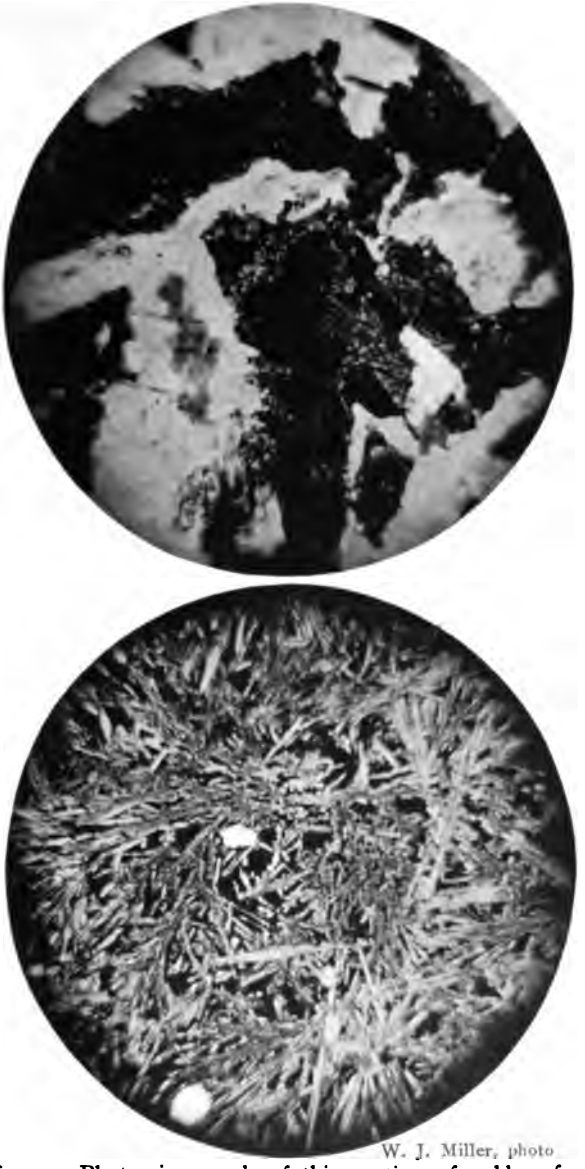
In the upper figure the large central mineral is olivine completely surrounded by successive rims of hypersthene, biotite (narrow and dark), and garnet. Surrounding all are broad laths of labradorite.

In the lower figure the large, black, central mineral is ilmenite, followed by successive rims of biotite, hornblende, garnet and biotite. The second and third — biotite and hornblende — rims are not separable in the photograph. Surrounding all are labradorite crystals.

Digitized by Google

Digitized by Google

Plate 6



W. J. Miller, photo

Upper figure. Photomicrograph of thin section of gabbro from the top of Hackensack mountain. Magnified 15 diameters. The central mineral, with good cleavages nearly at right angles, is diallage which is almost completely surrounded by a zone of hornblende (darker colored). As seen under the microscope the rim is very clearly defined. The light gray minerals are basic plagioclase. The diabasic texture of the rock is well shown.

Lower figure. Photomicrograph of a thin section of diabase from the dike one and one-half miles southeast of Johnsburg. Magnified 15 diameters. The long, slender prisms with transverse cracks are augite; the smaller, more numerous, prisms arranged in more or less sheaf like bundles are basic plagioclase; the black areas are glassy groundmass; and the four small, white rounded areas represent quartz, probably of secondary origin.

Digitized by Google

Digitized by Google

markable manner in the North Creek region gabbros. In the examples most often described the core is olivine, but in the gabbros here considered the writer has observed cores of olivine, hypersthene, ilmenite, augite, and diallage with from one to five distinct, successive rims surrounding the cores. Professor Kemp has described [1] and figured a number of interesting examples of reaction rims observed in certain gabbros of the eastern Adirondacks.

The following nine types of reaction rims comprise most of those noted by the writer in the North Creek gabbros:

1 Ilmenite surrounded by hornblende.
2 Diallage surrounded by hornblende.
3 Augite surrounded by hornblende.
4 Hypersthene surrounded by garnet.
5 Hypersthene surrounded by successive zones of biotite and hornblende.
6 Olivine with successive zones of hypersthene, hornblende, and garnet.
7 Olivine with successive zones of hypersthene, biotite, and garnet.
8 Hypersthene with successive zones of biotite, feldspar, and garnet.
9 Ilmenite with successive zones of biotite, hornblende, garnet, and biotite.

In nearly all cases the material immediately inclosing the rims is feldspar which, in a sense, adds another zone to each of the above. No. 6 is like one of those described by Kemp. No. 9 is a remarkable example and, because of its additional outer rim of biotite, is even more interesting than a case described by Lacroix.[2] Some of the others may be new examples. The material of each rim appears to be highly granulated or at least made up of numerous small grains. It seems certain that where hypersthene envelops olivine, the former has secondarily developed from the latter. The olivine cores are of very irregular shapes and in all sizes. Where hypersthene forms the core it is probable that all the original olivine has been altered to hypersthene. The common occurrence of hornblende rims around pyroxene strongly suggests the derivation of the former from the latter. Garnet is almost invariably in contact with feldspar which suggests the partial formation, at least, of the garnet from the feldspar.

[1] Geol. Soc. Amer. Bul., 1894, 5:218–21.
[2] Bul. Soc. Min. Fr., 1889, 12:232.

Digitized by Google

Chemical composition, norm, and mode

Excellent exposures of what is regarded as very typical gabbro occur in the railroad cut 1¼ miles south of The Glen. This rock has been analyzed for the writer by Prof. E. W. Morley.

TABLE 5

Chemical composition and norm

	Per cent	Mol	Ilm	Ap	Na Cl	Pyr	Orth	Alb	An	Mag	Diop	Hyp	Ol
SiO_2	46.40	.773					72	258	168		152	69	54
Al_2O_3	14.17	.139					12	43	84				
Fe_2O_3	2.03	.013								13			
FeO	13.12	.182	38			2				13	76	69	108
MgO	4.94	.124											
CaO	9.65	.172		20					84		68		
Na_2O	3.14	.050			7			43					
K_2O	1.12	.012					12						
H_2O+	.02												
H_2O-	.25												
TiO_2	3.03	.038	38										
P_2O_5	.80	.006		6									
Cl	.15	.004			15								
MnO	.44	.006									6		
S	.14	.005				5							
BaO	.18	.001									1		
SrO	.10	.001									1		
F	.04	.002											
ZrO_2	.05	.000											
	99.77												

Orth	6.67
Alb	22.53
Anor	23.35
NaCl	.82
Ilm	5.78
Mag	3.02
Pyr	.24
Apat	2.02
Diop	17.53
Hyper	8.02
Oliv	9.32
H_2O+ZrO_2	.32
	99.62

Sal.= 53.37 Class, $\frac{Sal.}{Fem.} = \frac{53.37}{45.93} < \frac{5}{3} > \frac{3}{5}$ = III, Salfemane

Order, $\frac{QL}{F} = \frac{.82}{52.55} < \frac{1}{7}$ = 5, Gallare

Fem.= 45.93 Rang, $\frac{K_2O^1 + Na_2O^1}{CaO^1} = \frac{62}{84} < \frac{5}{3} > \frac{3}{5}$ = 3, Camptonase

Subrang, $\frac{K_2O^1}{Na_2O^1} = \frac{12}{50} < \frac{3}{5} > \frac{1}{7}$ = 4, Camptonose

Digitized by Google

TABLE 6

Mode of gabbro

	Units measured	Rel. vols.	S. G.	Units by weight	Percentage weights
Plagioclase	2 805	38.09	2.66	7 461	32.72
Orthoclase	335	4.55	2.56	858	3.77
Hornblende	1 990	27.02	3.20	6 368	27.92
Hypersthene	932	12.65	3.50	3 262	14.30
Biotite	505	6.86	3.20	1 616	7.09
Augite	227	3.08	3.30	749	3.29
Garnet	265	3.59	3.70	980	4.30
Ilmenite	184	2.50	5.17	951	4.17
Pyrite	95	1.29	5.00	475	2.08
Apatite	26	.35	3.20	83	.36
	7 364	99.98	.....	22 803	100.00

Under the old qualitative system the rock is a hornblende norite, while according to the quantitative system it is a hornblende-camptonose. In thin-section the plagioclase is seen to range from oligoclase to labradorite, and the analysis and mode show that the average composition is that of a basic andesine. The high TiO_2 of the analysis shows either ilmenite or very titaniferous magnetite, the ilmenite being far more probable because of the difficulty of otherwise accounting for such a low content of Fe_2O_3.

Digitized by Google

TABLE 7
Adirondack gabbro analyses compared

	1	2	3	4	5	6	7
SiO_2	46.40	47.88	47.42	47.16	46.74	44.97	44.77
Al_2O_3	14.17	18.90	17.34	14.45	16.63	15.40	12.46
Fe_2O_3	2.03	1.39	4.91	1.61	2.17	2.29	4.63
FeO	13.12	10.45	10.22	13.81	10.60	12.39	12.99
MgO	4.94	7.10	5.21	5.24	6.11	10.89	5.34
CaO	9.65	8.36	8.09	8.13	8.66	7.50	10.20
Na_2O	3.14	2.75	3.48	3.09	3.81	3.02	2.47
K_2O	1.12	.81	1.89	1.20	.86	.56	.95
H_2O	.27	.61	1.13	.60	.85	.75	.60
CO_2	.....	.12	.....	.35	.07	.23	.37
TiO_2	3.03	1.20	3.60	3.37	2.54	1.18	5.26
P_2O_5	.80	.20	.06	.57	.33	.14	.28
S	.14	.07	.....	.14	.11	.06	.26
MnO	.44	.16	.06	.24	.26	.22	.17
NiOCoO	.....	.02	.....	.02	.03	.02	.....
V_2O_5	.....	.....	.....	.....	.....	.02	.....
Cl	.15	.....	.21	.....	.....	.....	.....
F	.04	.....	.....	.....	.....	.....	.....
BaO	.18	.....	.04	.....	.....	.....	.....
SrO	.10	.....	.....	.....	.....	.....	.....
ZrO_2	.05	.....	.....	.....	.....	.....	.....
	99.77	100.02	100.01	99.98	99.77	99.72	100.75

1 One and one-quarter miles south of The Glen, Warren County. E. W. Morley, analyst. Described by W. J. Miller.

2 Split Rock Mine, Westport, Essex county. W. F. Hillebrand, analyst. Described by J. F. Kemp.

3 Dike near Nicholville, St Lawrence county. E. W. Morley, analyst. Described by H. P. Cushing.

4 Woolen Mill, one mile west of Elizabethtown, Essex county. W. F. Hillebrand, analyst. Described by J. F. Kemp.

5 Two miles south of Elizabethtown, Essex county. W. F. Hillebrand, analyst. Described by J. F. Kemp.

6 Same exposure as no. 5. W. F. Hillebrand, analyst. Described by J. F. Kemp.

7 Lincoln Pond, Essex county. George Steiger, analyst. Described by J. F. Kemp.

These analyses show the Adirondack gabbros to be very similar in composition, the only notable variations being in the contents of Al_2O_3, MgO, and TiO_2. The North Creek sheet gabbro (no. 1) agrees most closely with no. 4.

Cause of the primary variations

In attempting to account for the primary variations of these gabbros, the writer believes there is strong evidence favoring the application, to a greater or lesser extent, of Daly's magmatic stoping

Digitized by Google

and assimilation hypothesis to the solution of the problem. For full discussions of this hypothesis the reader is referred to Daly's original papers.[1] Some of the more fundamental principles are as follows: Batholithic (or stock) magmas have reached their present positions chiefly by the successive engulfment of blocks of country rock (xenoliths) stoped or broken out of the roof and walls of the magma chamber; the xenoliths become immersed and dissolved in the depths of the original magma with the formation of a secondary magma; when the magma becomes very viscous (due to cooling) the xenoliths neither sink nor become dissolved.

Only a summary of the application of these principles to the North Creek gabbros will here be given, the writer having more fully discussed this matter in a recent paper.[2]

We have shown that the gabbro stocks are of the pluglike or pipelike form with practically vertical boundaries. Such igneous masses were not intruded by simply displacing or pushing aside the country rock, but rather there was a process of replacement. Thus the mode of occurrence of these stocks furnishes strong evidence in favor of magmatic stoping as an important factor in the intrusion.

The very presence of the inclusions as xenoliths proves that the process of stoping or rifting off blocks from the chamber vault actually did take place to some extent at least, and this when the magma had cooled to a highly viscous condition and hence had comparatively little power to stope and too low a temperature to assimilate the blocks. Thus the occurrence of such xenoliths is quite in harmony with Daly's hypothesis.

The writer believes that the more acidic patches or masses (already described) within the gabbro stocks are evidence of chemical change within the intrusive magma due to solution or partial solution and diffusion of blocks of country rock. In such cases the magma was just hot enough to melt or partially melt and only partially diffuse the blocks of country rock.

Five or six of the stocks are composed wholly of rocks more acidic than the typical gabbro. In the earlier stage of very active intrusion the invading magma was more thoroughly molten and as the blocks of country rock were stoped off they sank in the magma and became thoroughly dissolved and diffused. Since the country rock was nearly always syenite, granite, or gneiss the magma became more and more acidic.

[1] Amer. Jour. Sci. 1903, 15:269–98; Amer. Jour. Sci. 1903, 16:107–26; Amer. Jour. Sci. 1908, 26:17–50.

[2] Jour. of Geol. 1913, 21:160-80.

Digitized by Google

Contact phenomena

A very interesting case of contact metamorphism produced by the action of the gabbro on granite may be seen at the southern end of the large stock just south of Mountain Spring lake. In a recently opened stone quarry, and about 75 feet higher than the road on its east side, the rocks are laid bare in such a manner that an excellent opportunity is afforded for the study of the contact zones. The following nine zones, passing from the typical gabbro to the typical granite (country rock), have been studied in detail in the field and by means of thin sections and hand specimens.

Zone 1 Typical gabbro well within the gabbro stock. Nearly black, medium grained, and with diabasic texture. (Gradation from 1 to 2)

Zone 2 Syenitic phase of gabbro stock and within a few feet of the granite. Dark gray, medium grained, and with granitoid texture. (Gradation from 2 to 3)

Zone 3 One to three feet wide. Biotite-schist border phase of the gabbro stock. Secondary origin. (Sharp contact between 3 and 4, gabbro and granite)

Zone 4 Four inches wide. Hornblendite phase of the country rock. Nearly black, medium grained, banded parallel to gabbro-granite contact. (Fairly sharp contact between 4 and 5)

Zone 5 Six inches wide. Monzonitic phase of the country rock. Yellowish gray, medium to coarse grained, and banded parallel to the main contact. (Not very sharp contact between 5 and 6)

Zone 6 Fifteen to eighteen inches wide. Chiefly hornblendite phase of the country rock but with numerous very narrow streaks of no. 5. Nearly black, medium grained, and banded parallel to the main contact. (Sharp contact between 6 and 7)

Zone 7 Three and one-third feet wide. Monzonitic phase of the country rock like no. 5. Yellowish gray, fairly coarse grained, and banded parallel to the main contact. (Not very sharp contact between 7 and 8)

Zone 8 Seven feet wide. Monzonitic phase of the country rock. Light gray, fairly coarse grained, and not banded. (Gradation from 8 to 9)

Zone 9 Typical (country rock) granite. Pink, medium grained, and very gneissoid but with gneissic bands striking at almost right angles to the main contact.

Digitized by Google

TABLE 8

Mineralogical composition of each contact zone

Zone no.	Orthoclase	Microperthite	Microcline	Plagioclase	Hornblende	Hypersthene	Quartz	Biotite	Magnetite	Zircon	Zoisite	Pyrite	Garnet
1	5	....	....	Ol-lab 45	14	20	....	6	2	.....	.....	1	2
2	32	....	....	Ol-lab 10	45	....	....	6	2	little	.....	little	5
3	Biotite-schist with some feldspar												
4	Like No. 6												
5	28	.....	.....	Ol-and 50	20	....	1	....	½	little	little	.....	....
6	15	.....	.....	Ol-and 5	72	....	....	....	7	½	½	little	
7	Like No. 5												
8	33	....	....	Ol-and 55	10	....	1	....	....	½	½	little	
9	40	15	4	Ol-and 5	5	....	30	....	½	little	.....	.....	½

A noteworthy feature is the fact that the strike of the foliation of the very gneissoid country rock is nearly at right angles to the gabbro-granite contact, while the clearly defined contact zones are parallel to the contact.

Other features of special interest are the syenitic border (except for the secondary biotite-schist) of the gabbro near the contact, and the almost complete absence of quartz from the granite within a dozen feet of the main contact. Thus the country rock (granite) is distinctly more basic near the contact, while the gabbro is distinctly more acidic near the contact.

Whether these interesting endomorphic and exomorphic changes are to be accounted for on the basis of assimilation of some of the country rock during the intrusion of the gabbro, or on the basis of the action of vapors from the intrusive, it at least appears quite certain that the gabbro must have been considerably superheated in order to have so notably affected the granite. As judged by the mode of occurrence of the gabbro stock, the stoping hypothesis recently advocated by Daly or the hypothesis of marginal assimilation might be applied to account for the more acidic border phase of the gabbro, but the sharp contact of the gabbro against the granite would seem to preclude the possibility of accounting for the more basic contact zones of the country rock on the basis of actual assimilation of some of the granite by the gabbro.

Digitized by Google

PEGMATITE

The most interesting thing about the pegmatite is its distribution, because it is very commonly directly associated with the gabbro masses. Many times the pegmatite, in the form of dikes or veins, may be seen cutting the gabbro (see plate 4) and hence the younger age of the pegmatite. This direct association of the very acid pegmatite with basic gabbro and its age intermediate between the basic intrusives — gabbro and diabase — are rather anomalous features for which the writer can offer no explanation.

Among other places where pegmatite may be seen cutting the gabbro are: (1) at the top of Hackensack mountain; (2) 1¼ miles south-southeast of Potter mountain; (3) 1¼ miles a little east of north of The Glen; (4) 1 mile south-southeast of The Glen; (5) 1⅓ miles northeast of Pottersville; (6) 1⅔ miles southeast of Chestertown; (7) 2½ miles southeast of Chestertown; and (8) 2¾ miles south-southeast of Chestertown. At most of these places the gabbro is shot through with small pegmatite veins. At the fourth named locality one dike is 50 feet long and 25 feet wide and very rich in big orthoclase and albite feldspar crystals. At the seventh named locality a small pegmatite dike contains fine crystals of biotite, muscovite and black tourmaline. At the sixth and eighth named localities there are pegmatite dikes 50 to 100 feet long with books of muscovite up to 5 or 6 inches across at the eighth locality.

Large pegmatite dikes are not common away from the gabbro, there being but two examples worthy of mention namely: just east of the old garnet mine south of Daggett pond where there are many poorly formed black tourmaline crystals up to 6 inches long, and one-quarter of a mile above the mouth of Mill creek where there is a dike 200 feet long and 40 feet wide in granitic syenite.

DIABASE

Mode of occurrence and distribution

In striking contrast with the neighboring gabbro, the diabase invariably occurs in typical dikes which have clearly broken through narrow fissures in the country rock. They vary in length from 20 or 30 feet to 200 yards, and in width from 5½ inches to 40 feet.

The chief features of occurrence are brought out in the following description of the largest dike of the region which lies at the western base of Heath mountain or 3 miles west-northwest of Warrensburg. This dike has a maximum width of 40 feet and a length of 200 yards. It is fine to medium grained toward the interior and very

Digitized by Google

fine grained along the borders. It breaks through both Grenville and granite gneisses and the contacts are everywhere perfectly sharp, there being no evidence whatever of contact metamorphism. A number of small tongues, from 1 inch to 3 or 4 feet wide, branch off the large dike and extend as much as 25 or 30 feet into the country rock. One of these branches cuts a pegmatite dike and another cuts Grenville limestone. This large dike strikes across the foliation almost at right angles.

One and one-half miles southeast of Johnsburg a diabase dike, 2½ feet wide and 60 feet long, cuts Grenville quartzite parallel to the foliation. All of this rock is fine grained but exceptionally so at the contacts, and on one side an inch wide zone of basaltic glass or obsidian is perfectly developed with some very small tongues of glass extending into the country rock.

A typical diabase dike 4 feet wide cuts the gabbro stock three-quarters of a mile south of Warner pond. The dike has fine grained borders, sharp contacts against the gabbro, and is clearly traceable for 150 feet or more.

In all eleven diabase dikes were found, being well scattered over the quadrangle. Most of them cut across the foliation of the country rock at high angles, thus differing from the gabbros, and they probably have been forced up along joint planes. In nine of the eleven occurrences the dikes strike northeast and southwest which is quite the rule for such dikes in the eastern Adirondacks. So far as can be determined, these dikes all come up vertically through the country rock.

Megascopic and microscopic features

The diabase is a very dark bluish gray to almost black rock which, in all exposures, is hard and fresh except for the immediate surface which is often weathered to reddish brown.

The granularity and texture vary from glassy to very fine grained to medium grained diabasic, the finer grained rock being wholly confined to the borders and the diabasic texture nearly always being just visible to the naked eye in the typical medium grained rock. Except for the above named differences the diabase shows no facies whatever visible to the naked eye, and this again is in marked contrast with the gabbros. The diabase is wholly devoid of any metamorphism and inclusions of country rock are never found. The only minerals recognizable by the naked eye are the tiny feldspar laths and an occasional pyrite speck.

Digitized by Google

The whole range in mineralogical composition is brought out in the following table:

TABLE 9

Mineralogical composition of the diabase

	Slide no.	Andesine to labradorite	Augite	Biotite	Ilmenite	Pyrite	Glassy ground mass	Quartz	Apatite
1	8	47	25	22.5	4	½	.....	little	little
			37						
2	48	55	Mostly chlorite		6	little	.....	2	little
			40						
3	7	55	Mostly chlorite.		5	....	.....	little	little
4	10	5	5	.....	many specks	....	85	....	.....
5	9	55	14	.....	5	little	25	1	.....

The remarkable similarity in composition is a striking feature. Nos. 1, 2, and 3 are typical holocrystalline diabases from widely separated dikes. Nos. 4 and 5 represent finer grained or border phases and have more or less glassy ground mass. No. 5 presents a striking appearance under the microscope because the feldspar crystals which are incipient and almost indeterminate tend toward sheaflike bundles (see plate 6, lower figure).

Number 1 of table 9, which may be regarded as typical of all the diabases, is from the large dike (above described) at the base of Heath mountain. The fine to medium grained rock shows an excellent diabasic texture visible even to the naked eye. Judging by the extinction angles, the broad laths of somewhat decomposed plagioclase range from andesine to labradorite in composition. Pale reddish brown augite, in stout prisms, shows a very faint pleochroism. It exhibits good cleavage and sometimes good crystal boundaries. The biotite is much changed to chlorite and stained with black iron oxid. The ilmenite often shows transition to leucoxene. Apatite occurs in tiny needles, and pyrite and quartz in small irregular grains, the latter being probably of secondary origin.

Chemical composition, norm, and mode

The diabase from the dike at the western base of Heath mountain has been analyzed for the writer by Prof. E. W. Morley.

Digitized by Google

TABLE 10

Chemical composition and norm of diabase

	Per cent	Mol	Ilm	Apat	Fluor	Na Cl	Orth	Alb	An	Mag	Diop	Hyper	Quartz
SiO_2	50.57	.843					120	276	134		126	153	34
Al_2O_3	13.58	.133					20	46	67				
Fe_2O_3	3.26	.020								20			
FeO	10.09	.140	33							20	26	61	
MgO	4.98	.124									37	87	
CaO	7.67	.137		7	2				67		61		
Na_2O	2.92	.047				1		46					
K_2O	1.89	.020					20						
H_2O+	.16												
H_2O-	.94												
TiO_2	2.68	.033	33										
P_2O_5	.28	.002		2									
Cl	.09	.002				2							
F	.09	.005		1	4								
MnO	.36	.005										5	
BaO	.09	.001									1		
SrO	.10	.001									1		
S	.03												
Total	99.78												

Qtz	2.04	
Orth	11.12	
Alb	24.10	Sal.= 56.01
Anor	18.63	
NaCl	.12	
Mag	4.64	
Ilm	5.02	
Apat	.67	
Fluor	.16	Fem.= 42.34
Diop	14.44	
Hyper	17.41	
H_2O+S	1.13	
Total	99.48	

$$\text{Class, } \frac{\text{Sal.}}{\text{Fem.}} = \frac{56.01}{42.34} < \frac{5}{3} > \frac{3}{5} = \text{III, Salfemane}$$

$$\text{Order, } \frac{QL}{F} = \frac{2.26}{53.85} < \frac{1}{7} = 5, \text{ Gallare}$$

$$\text{Rang, } \frac{K_2O^1 + Na_2O^1}{CaO^1} = \frac{67}{67} < \frac{5}{3} > \frac{3}{5} = 3, \text{ Camptonase}$$

$$\text{Subrang, } \frac{K_2O^1}{Na_2O^1} = \frac{20}{47} < \frac{3}{5} > \frac{1}{7} = 4, \text{ Camptonose}$$

TABLE 11

Mode of diabase

	Units measured	Rel. vols.	S. G.	Units by weight	Percentage weights
Plagioclase	2 027	46.88	2.66	5 392	40.78
Biotite	975	22.55	3.20	3 120	23.59
Ilmenite	168	3.88	5.17	868	6.56
Augite	1 090	25.21	3.30	3 597	27.20
Pyrite	30	.69	5.00	150	1.13
Quartz	26	.60	2.65	69	.52
Apatite	8	.18	3.20	26	.19
	4 324	99.99	.....	13 222	99.97

Digitized by Google

Thus, according to the old qualitative classification, the rock is a biotite-diabase, while under the new quantitative chemical classification it is a biotite-camptonose. The amounts of SiO_2, Al_2O_3, and CaO in the analysis strongly bear out the determination of the plagioclase as ranging from andesine to labradorite. Such a high content of FeO in the analysis makes it certain that the biotite is rich in ferrous iron, since there is not enough magnetite and augite to account for so much FeO. The sulphur appears too low as judged by the amount of pyrite visible even to the naked eye. The high TiO_2 shows either ilmenite or that the magnetite is decidedly titaniferous, though a little of the TiO_2 may be in the biotite. The low Fe_2O_3 content in the analysis favors the presence of ilmenite.

It is important to note that the analyses of the diabase and typical gabbro are very similar except for somewhat higher silica and lower lime in the diabase, this difference probably being due to the slightly more acid character of the plagioclase in the diabase. Thus the two rocks have quite certainly been derived from the same source of basic supply though at different times.

TABLE 12

Adirondack diabase analyses compared

	1	2	3	4	5	6
SiO_2	50.57	43.41	44.51	45.46	46.73	50.89
Al_2O_3	13.58	19.42	19.99	19.94	16.66	15.39
Fe_2O_3	3.26	5.72	7.22	15.36	3.56	5.77
FeO	10.09	6.69			8.45	
MgO	4.98	5.98	8.11	2.95	8.12	7.60
CaO	7.67	9.11	8.15	8.32	8.03	8.75
Na_2O	2.92	4.39	5.24	2.12	3.73	5.67
K_2O	1.89	.47	2.60	3.21	1.64	2.72
H_2O	1.10	3.00	2.93	2.30	2.39	2.46
TiO_2	2.68	.35	.....	.....	.03	.....
P_2O_5	.28	.....	.....	.....	.39	.....
Cl	.09	.....	.....	.....	.18	.....
F	.09	.....	.....	.....	.26	.....
Cr_2O_3	.....	.....	.....	.....	.06	.....
MnO	.36	.....	.....	.....	trace	.....
BaO	.09	.....	.....	.....	.04	.....
SrO	.10	.....	.....	.....	.....	.....
S	.03	.....	.....	.....	.....	.....
CO_2	.....	2.00	.....	.....	.....	.....
	99.78	100.54	98.75	99.66	100.27	99.25

Digitized by Google

1 From western base of Heath mountain, North Creek sheet, Warren county. Analyst Morley.

2 From summit of Mt Marcy, Essex county. Analyst Leeds. N. Y. State Mus. 30th Annual Rep't, p. 102.

3 From shore of Upper Chateaugay lake, Clinton county. Analyst Eakle. Amer. Geol. July 1893, p. 35.

4 From Palmer Hill, Black Brook township, Clinton county. Analyst Kemp. U. S. Geol. Surv. Bul. 107, p. 26.

5 From Bellmont township, Franklin county, dike 13. Analyst Morley. N. Y. State Geol. 18th Annual Rep't, p. 120.

6 From shore of Upper Chateaugay lake, Clinton county. Analyst Eakle. *Op. cit.*, p. 35.

The North Creek sheet diabase (no. 1) is lower in Al_2O_3 and CaO, and higher in TiO_2 than any of the others. It is also somewhat more acid than usual for the diabases, due to the more acid character of the plagioclase feldspar.

Lack of variation of the diabase

Because of its remarkable homogeneity in composition, the diabase presents a marked contrast to the neighboring gabbro. The diabase never contains inclusions and, with a single very local exception below described, never shows any evidence of magmatic assimilation even in the largest masses. This difference is quite certainly due to the difference in the mode and condition of intrusion, the diabase having clearly been forced through comparatively narrow fissures in the country rock and near the earth's surface as the texture shows. In such intrusions magmatic stoping would be reduced to a minimum or absent.

Contact phenomena

A small dike, 5½ inches wide, which cuts the Grenville limestone at the asbestos mine three-quarters of a mile southeast of Thurman, shows contact phenomena which deserve special mention. Following is a description based upon thin sections and hand specimens (see plate 7).

Zone 1 This is typical, unaltered, medium grained, greenish gray, serpentine marble.

Zone 2 This zone, about one-third of an inch wide, lies along the contact with the diabase. It consists of a fine grained, dark green, well-baked serpentine marble.

Zone 3 One-sixth of an inch wide. Nearly black (greenish gray in thin section), glassy looking dike rock which shows an irregular but sharp boundary against the marble. It appears to consist

Digitized by Google

largely of rather homogeneous, serpentinous material (bluish gray interference tints) which is apparently igneous glass into which serpentine marble has been fused. Occasional well-formed laths of plagioclase and many specks of magnetite occur. The outer 1 or 2 millimeters of this zone are very rich in magnetite specks. This zone shows a rapid transition into the next one.

Zone 4 One-third of an inch wide. Reddish brown, glassy looking. Apparently good igneous glass filled with many tiny specks of what seem to be magnetite and perhaps 10 per cent of plagioclase mostly in laths but some in stout prisms with distinct zonal structure. This grades perfectly into the next zone.

Zone 5 One-half of an inch wide. Pale green color and much like no. 4 except for absence of the tiny specks. The green color is due to serpentinous material which appears to have been absorbed by the molten mass. The contact between this and the next zone is rugged though pretty sharp.

Zone 6 Ordinary bluish black diabase from within the dike and with no serpentinous admixture. This rock is mostly a dark glass which contains 5 per cent plagioclase laths and 5 per cent pale reddish brown, euhedral augite crystals and numerous specks of presumably magnetite.

PALEOZOIC OUTLIERS

No actual outcrop of Paleozoic strata has been found within the borders of the quadrangle, but certain nearby Paleozoic outliers have an important bearing upon the geologic history of the region. Two of these outliers have been described by Professor Kemp, one of them being Little Falls dolomite which occurs at Schroon Lake village (Schroon Lake sheet), and the other being Potsdam sandstone which occurs near the village of North River (Thirteenth Lake sheet).

During the summer of 1910 the writer discovered a small Paleozoic outlier 1 mile south of the map edge and 1 mile due west of High Street village (Luzerne sheet). The exposures are rather poor and small but the rock is quite certainly in place with the strata lying in nearly horizontal position. Both sandstone and dolomite beds occur and it is not certain whether the rocks represent the passage beds of the Theresa formation or the contact between the Potsdam and the Little Falls dolomite, though the former is more probable. This outlier lies at 1400 feet elevation and not far to the west of the No. 9 mountain fault and on its downthrow side.

Digitized by Google

The important outlier at Wells (Lake Pleasant sheet), which shows rocks from Potsdam to Canajoharie, has been known since the early days of the State Survey. The nearby occurrences of Little Falls dolomite along the southern portion of Lake George should also be mentioned.

Within the map limits, certain drift boulders are significant as showing proximity to concealed outcrops or ledges which were scraped off by ice erosion. Thus a fragment of Potsdam sandstone 2 feet across and very angular was seen just east of the old garnet mine near Daggett pond, and many Potsdam fragments up to 1 foot across occur in the river valley bottom between Moon and Heath mountains.

The occurrences of early Paleozoic marine strata on all sides of the North Creek quadrangle furnish practically conclusive evidence that much, if not all, of the area of the quadrangle was covered by that early Paleozoic sea. Thus the Potsdam (upper Cambric) sea, which encroached over northern New York from the northeast, must have swept over the North Creek region and this was quite certainly succeeded by the Theresa and Little Falls seas. Regarding the presence or absence of the Ordovician sea, we have no positive knowledge, though the Wells outlier suggests that it, too, was present.

It is well known that when the Potsdam sea encroached upon the eastern Adirondacks, the region was greatly worn down to the condition of nearly a peneplain. Since some portions stood out above the general level of the peneplain, it is quite possible that the Potsdam sea, and even the later Cambric, did not cover the higher portions as Professor Kemp has suggested. At any rate the evidence is strong that very much if not all of the North Creek area was covered by the late Cambric sea and probably also by the Ordovician sea. The deposits made in those seas have all been removed by erosion except for the small outlying masses above described. It is important to note that each one of these outliers has been very considerably faulted downward from the original position of the strata and thus they have been protected against complete removal by erosion during so many million years.

STRUCTURAL FEATURES

FAULTS

General considerations. That the eastern Adirondacks are extensively faulted has been recognized for some years, but thus far comparatively little attention has been paid to the detailed study

Digitized by Google

and mapping of these faults well within the Precambric area. The North Creek quadrangle, which lies in the midst of this eastern Adirondack faulted region, is literally cut to pieces by faults. On the accompanying geologic map the writer has indicated the positions of over forty faults, most of which show unmistakable evidences of their presence, while the others, shown on the map by the heavy broken lines, are more or less certainly present.

The faults are all of the normal type with fault planes vertical or very steep. Because of the character and structure of the rock masses and the lack of any well-defined stratigraphic relations, it is practically impossible to determine the actual amounts of displacement, though in many cases minimum approximations can be made. Such minimum figures commonly range from a few hundred to a thousand feet or more. One feature worthy of special mention is the frequent rapid diminution of throw within very short distances. Thus in many respects the North Creek faults are much like those of the Mohawk and Champlain valleys, which is to be expected as the faults of this whole eastern Adirondack region were all produced at the same time or times. With regard to the strike, however, the North Creek faults are rather exceptional because the general trend of the Adirondack faults is north-northeast by south-southwest, while within the North Creek quadrangle this trend is the rule only in its northern portion.

As a rule, faults within the Precambric area are difficult to locate and trace with any great degree of accuracy and certainty because of the general similarity of the rocks and the lack of ordinary fossiliferous strata. In the North Creek region, however, the conditions are particularly favorable for locating faults both because of the unusual excellence of exposures and the large amount of widely distributed weak Grenville strata.

Frequently the line of contact between the syenite or granite and the Grenville is very regular and sharp, the Grenville often seeming to dip under the igneous rock with the latter rising abruptly and to a great height above the Grenville. Among the best examples of such phenomenon are the southern sides of Huckleberry, Crane, and Little mountains, and the western sides of Oven, Prospect, Birch, and Potter mountains. There are only two possible explanations of this phenomenon, namely, either that the igneous rocks were intruded into the positions which they now occupy or that faulting has occurred. If this is to be explained simply on the basis of intrusion, then we are forced to assume a remarkably irregular surface

Digitized by Google

all
u-
of

he
ps
rd

lts
:d,
to
ım
'n-
ıal
ıg,
ks,

'ed
:ar
ıve
gle
:r's
the
ılt,
of
:he
ınd
ult.
ing

red
:di-
ong
has
of
ere
nce
one
ave
hat

Digitized by Google

anc
No
Ad
the
tio
der
hea
T
or
ma
is
pla
ma
to
is
tan
like
exp
all
hov
ger
sou
the
A
anc
of
sili
tio
the
dis
I
the
to
to
suc
Lit
anc
of
tru
has
tru

Digitized by Google

of the newly cooled magma and also that the molten masses, in all these cases, broke through the Grenville along very straight or regular lines often for miles. Both of these assumptions are out of harmony with well-known observations in other regions.

The very common dip of the Grenville downward against the faults is due to the fact that most of the prominent fault scarps face the west while the prevailing dip of the Grenville is toward the east.

Among the more positive criteria for the recognition of the faults are the following: (1) actual steep to vertical scarps, often in hard, perfectly homogeneous rock, and frequently in such positions as to preclude the possibility of their having been formed by ice or stream erosion; (2) the distinct tilting of the earth blocks gradually downward away from the scarps; (3) the frequent presence of actual crushed, sheared, or brecciated fault zones; and (4) the long, straight contact lines between the Grenville and the igneous rocks, with the latter rising abruptly high above the former.

What is the age of the faulting? That some, at least, occurred during Precambric time has been pretty well established but, so far as known, such faults are of minor importance and certainly have no appreciable influence upon existing topography. But a single case of such very ancient faulting has come under the writer's notice within the area of the quadrangle and this occurs along the road three-fifths of a mile southwest of Sullivan pond. A fault, plainly visible for 12 feet, there passes across a glaciated ledge of quartz syenite. On the east side, for a width of 7 or 8 feet, the whole mass is a fault breccia. This breccia is fine at the fault and coarser, with fragments up to 1½ feet across, away from the fault. The fault strikes north 30° east and is in no way related to existing topography.

There is good reason to think that considerable faulting occurred during the Paleozoic era after the deposition of the Ordovicic sediments because rocks of that age are involved in the faulting along the eastern and southern borders of the Adirondacks. Cushing has suggested that the faulting may have been initiated at the time of the Taconic revolution when the rocks immediately eastward were so greatly disturbed, but he says:[1] "The great earth disturbance (Appalachian revolution) which prevailed in the Appalachian zone toward the close of the Paleozoic would seem more likely to have brought about the major faulting of the region." We know that

[1] N. Y. State Mus. Bul. 95, p. 405.

Digitized by Google

the whole State was then upraised practically without folding, and the conditions were certainly favorable for extensive fracturing of the strata.

Any fault scarps or ridges produced during or at the close of the Paleozoic must have been quite or nearly obliterated during the long Mesozoic period of erosion. If so, how do we account for the present Adirondack ridges which follow fault lines? As a result of the uplift of the Cretacic peneplain one or both of the following things happened, namely, either that there was renewed faulting or that, as a result of unequal erosion (due to differences in rock character) on opposite sides of the faults, the old fault scarps were renewed. It is quite certain that both things occurred and thus we account for the present Adirondack fault ridges. That some of the faulting actually dates from the uplift of the Cretacic peneplain, or possibly even later, is proved by the existence of certain fault cliffs in perfectly homogeneous rock masses, and by the fact that many of the tilted fault blocks have been little modified by erosion since their formation. Among many good examples of fault scarps in homogeneous rocks are those on the west sides of Moon, Kelm, and Chase mountains, while tilted fault blocks little affected by erosion are those of Moon, Birch, Crane and Huckleberry mountains.

Little-Crane-Huckleberry mountain faults. The structural relations shown by these three mountain masses are truly remarkable and the faults are the most interesting within the quadrangle. The deep, narrow rift between Huckleberry and Crane mountains was carefully examined and, judging by the frequency of outcrops, it is quite certain that a narrow belt of Grenville separates the mountain masses as shown on the map. A narrow valley of Grenville, chiefly limestone, with almost continuous outcrops separates Crane mountain from the granite ridge just south. Likewise there is a valley of Grenville, chiefly limestone, immediately to the south of the granite ridge (Little mountain and its westward extension).

In each case the mountain mass of igneous rock presents a high and very steep to almost precipitous wall on the south side, and in each case the belt of Grenville comes abruptly against the igneous rock wall. A slight exception to the latter statement is along the southwestern base of Crane mountain where a small belt of syenite intervenes between the Grenville and the high mountain mass. Almost invariably the rocks of the Grenville belts dip at high angles downward and against the faults. The great

Digitized by Google

Plate 8

W. J. Miller, photo

Crane mountain as viewed from Thurman village. This great dome of quartz-syenite rises 2000 feet above the valley at its base. The valley is underlain with Grenville, chiefly limestone. The steep slope on the left (south) side is due to a fault scarp, and the down tilt of the great mountain block toward the right (north) is plainly shown. The escarpment at the summit is due to the passage of a minor fault.

Digitized by Google

Digitized by Google

bare wall of syenite rising to a height of a thousand feet or more on the south side of Crane mountain is a truly impressive sight as viewed from the valley or ridge just to the south. As viewed from the summit of Crane mountain, the sharp-crested granite ridge forming the westward extension of Little mountain bears a close resemblance to a typical hogback ridge. All these mountain masses show decided, though much more gradual, downward slopes toward the north, this being perfectly shown by Crane and Huckleberry mountains and not so well by the Little mountain ridge. Thus the general areal distribution and structural relations of the rocks, more especially the long, regular or straight contact lines between the Grenville and igneous rocks; the high, steep walls of igneous rocks rising above the Grenville; and the distinct downward tilt of the mountain blocks northward and away from the scarps make the presence of three faults here practically certain. The picture of Crane mountain (plate 8) clearly shows the character of this earth block with its steep scarp on the south and long northward slope.

For reasons already stated, nothing like exact figures can be given as to the amounts of displacement but, judging by the present height of the scarps, the throw of Crane mountain fault appears to be more than a thousand feet, while the throw of the Huckleberry and Little mountain ridge faults are no less than 500 to 800 feet. The very rapid dying out of these faults is rather remarkable, but perhaps not more so than in the case of the Batchellerville fault of the Broadalbin quadrangle recently described by the writer.

As shown on the geologic map, a minor fault extends across the top of Crane mountain and parallel to the great fault just south. Three high points, 2682, 2829, and 3254 feet respectively, are arranged along the crest of the fault scarp with very steep south fronts or cliffs. The scarp on the south side of the highest peak (3254 feet) is a sheer precipice more than 200 feet high, which forms what is locally called the "Nose" of Crane mountain. It is well shown in plate 8. At several places the line of fracture is marked by distinct crushed or sheared zones where the rock is biotitic and almost like a schist in appearance.

The eastern face of Crane mountain rises abruptly along a straight line to a height of more than a thousand feet, and certainly bears every resemblance to a fault scarp. This topographic evidence,

[1] N. Y. State Mus. Bul. 153, p. 45.

Digitized by Google

together with the fact that this abrupt change in slope occurs in homogeneous syenite and away from any possible stream action, makes the presence of a fault here quite certain.

The eastern face of Little mountain is also very steep, much more so in fact than the contour lines indicate, and the general topographic and structural relations here also strongly suggest faulting. Some signs of shearing were noted. The northward extension of this fracture (dotted on the map) is more doubtful though the topography, not well shown on the map, points to minor faulting there. The strike of these two last named faults is almost exactly at right angles to the other larger faults of the group.

Moose-No. 9 mountain faults. The Moose mountain fault, as shown on the map south of Thurman village, is really only the northern end of a very prominent fault which has formed the steep escarpment along the eastern side of Moose mountain (Luzerne sheet).

No. 9 mountain fault strikes due north and south and has caused the steep western front of the mountain. Some evidence of shearing was noted. The displacement appears to have been no less than 500 feet, and the eastward downtilt of the earth block is evident.

Potter-Birch-Heath mountain faults. The Potter-Birch mountain mass is a fine illustration of a fault block with steep western front and gradual slope away from the scarp toward the east. On the western side of Birch mountain there is a very distinct shear zone along which the syenite has been badly crushed and made to appear much like a biotite schist. The Grenville, mostly limestone, dips at high angles eastward sharply against the syenite along the fault. The very distinct curving in of the fault against the syenite mass is here better shown than for any other fault of the quadrangle. The steepest portion of the scarp is at Daggett pond where an almost precipitous wall of syenite rises 555 feet above the pond. Judging by the present topography, the displacement of this fault ranges from 300 to 600 feet, being greatest at Potter mountain.

The Heath mountain mass is a good illustration of a small fault block eastwardly downtilted. The displacement is no less than 300 or 400 feet. It is possible that this fault is really a continuation of the Potter mountain fault, though it is more than likely a separate fracture as shown on the map.

The small mountain of syenite lying just across the river from Heath mountain is a still smaller fault block much like that of Heath mountain.

Digitized by Google

Moon-Hackensack mountain fault. This is a well-defined fault whose presence is proved by most of the criteria generally applicable in this region. The strike is northwest-southeast and in perfect harmony with that of Moon and Hackensack mountains. The trend of the fault scarp is clearly marked by the topography, the western face of Moon mountain being especially high and steep (see plate 9). Between the two mountains the scarp is lowest because the weaker Grenville there has been worn down most rapidly. This whole earth block shows the eastward downtilt, particularly in the case of Moon mountain. In a large prospect hole at the western base of Hackensack mountain and close to the road there is much evidence of shearing along the fault. Near the source of the small stream along the fault and half way between the mountains there is a fine exhibition of crushed and brecciated Grenville gneiss. Sheared rock was also noted along the western side of Moon mountain. The maximum throw of this fault appears to have been no less than 600 feet.

County House mountain fault. This fault is shown dotted on the map because its presence is not altogether certain. The steep eastern front of the County House-Kelm mountain masses and the fact that the Grenville (much limestone) comes in rather sharply against the bases of these mountains are the principal evidences for the faulting. The Grenville here, contrary to the usual thing, either dips away from the fault or its strike is at high angles against the fault.

Kelm mountain fault. This is a good example of a fault wholly within a mass of very homogeneous, igneous rock. The fault scarp is much more in evidence than the contour lines suggest, and there is a rather distinct eastward downtilt of the block. Shear zones were noted in two or three places. The displacement is as much as 300 feet.

Millington brook fault. This fault lies along the eastern side of the valley of Millington brook and strikes north-northwest by south-southeast. Where it crosses the road, 1¼ miles southwest of Kelm pond, the rocks are considerably sheared and brecciated. On the western side of the small mountain (1302 feet), near the north end of the fault, sheared rock was also noted. The extension of this fault southward to the western base of County House mountain is somewhat doubtful though the relations of the rock masses and the topography strongly suggest it. The throw of this fault is probably not over a few hundred feet.

Digitized by Google

Chase mountain fault. This fault strikes nearly north and south and the chief evidences for its existence are the very prominent scarp in the homogeneous granite porphyry and some suggestions of shearing. The usual tilted character of the blocks is not here shown. This fault probably continues southward to join the Millington brook fault as indicated on the map.

Tripp mountain faults. A fault whose trend is almost exactly north and south lies along the western base of Tripp mountain as shown on the map. The evidence for this fault is largely topographic, such as the presence of a very distinct scarp along a straight line for several miles in homogeneous igneous rock, and also the rather distinct downslope toward the east from the scarp. Near the south end of the fault and on the west side of the hill (1221 feet) some sheared rock was noted, but for most part the line of the fault is covered with rock debris. A maximum displacement of no less than 300 to 400 feet seems to be shown.

The southeastern face of Tripp mountain is a steep scarp which has almost certainly been produced by faulting because of its presence in homogeneous granite porphyry and away from any considerable stream. A throw of several hundred feet is represented.

Tripp pond fault. This fault strikes northwest-southeast and passes along the north side of Tripp pond and along the bases of the mountains whose elevations are respectively 1662 and 1389 feet. The very steep scarp rising to a height of 700 feet and forming the southwestern face of the mountain (1662 feet) just north of Tripp pond is almost certainly a fault scarp. At the opposite end of the fault the scarp is distinctly traceable along the southwestern face of the low mountain (1389 feet) and the little hill just southwest of Sullivan pond. The scarp here strikes at a high angle across the foliation and in homogeneous rock.

Bull Rock mountain faults. These two faults form the western boundary of the mass of syenite which lies along the east-central margin of the map. The shorter one strikes northwest-southeast and lies along the western border of the Bull Rock mountain mass, and the smaller mountain (1560 feet) just to the northwest. Grenville, chiefly quartzite, dips downward sharply against the fault.

The longer fault follows a perfectly straight line of hills or low mountains whose elevations are respectively 1560, 1512, 1200, and 1140 feet, the throw of the fault apparently gradually diminishing toward the north. The Grenville in the valley immediately west of the fault consists of various gneisses with varying dips and

Digitized by Google

Plate 9

W. J. Miller, photo

The Moon mountain fault-scarp as seen from directly across the Hudson river, which is just visible in the foreground. Many exfoliation slabs can be seen near the mountain top. A heavy (wooded) talus slope covers the base of the mountain. The rock is quartz syenite.

Digitized by Google

Digitized by Google

strikes. The usual evidences prove the faulting, the eastward downtilt of the fault block being especially well shown. Neither of the two faults just described has a maximum displacement of more than a few hundred feet.

Brant lake faults. A very prominent fault, which may be called the Brant lake fault, passes along the northern side of the lake of the same name within the adjoining Bolton sheet. The lake clearly occupies a depression at the base of this fault scarp. Only the western end of this fault comes into the North Creek quadrangle where it passes along the southern base of the mountain at the village of Horicon. It can not be traced across the Schroon river. Near the village of Horicon distinctly sheared and slickensided rock may be seen in the granite quarry. At the village the displacement appears to be no less than 400 or 500 feet.

On the south side of the narrow valley at Horicon a smaller fault, parallel to the larger one, is clearly indicated by a crushed zone in the granitic syenite. The eastward extent of this fault is not known.

Chestertown faults. A prominent fault with northwest-southeast strike lies along the southwestern base of Prospect mountain and is thought to be continuous with the fault shown on the map just east of Loon lake. These two are certainly exactly in line and, though they have not been positively connected, they will be regarded as parts of the same line of fracture. At the Loon lake end the fault shows an almost vertical scarp 300 feet high where it passes along the western border of the gabbro stock. The scarp there consists of badly sheared gabbro, and Grenville limestone dips directly against the base of the scarp. The southwestern side of Prospect mountain is a fine example of a high, steep fault scarp with banded Grenville gneisses dipping eastward against the base of the mountain which consists of a granitelike mass of gneiss. A displacement of no less than 700 feet is shown here. The southern end of the fault is marked by a rather steep scarp several hundred feet high and in the homogeneous granite porphyry.

There is fairly good reason to think that another fault with north-south strike passes through the western edge of the village of Chestertown, but since its presence is not certain it is represented on the map by a broken line. The fairly prominent scarp which forms a long straight boundary between the Grenville and the igneous rocks is the chief evidence for considering a fault here. The fault plane is mostly concealed by heavy drift.

Digitized by Google

The Glen-Riparius fault. This fault, whose length is some 8 or 9 miles, is clearly the longest one lying wholly within the quadrangle. It is topographically very plainly marked, a whole line of low mountain peaks forming the crest of the scarp. This great fault block shows a very distinct downtilt toward the east which accounts for the peculiar drainage condition because no considerable streams enter the Hudson river from the east along the line of the fault but, instead, the streams all drain from the crest of the scarp down the eastward slope and into the Friends and Loon lake basins. The Hudson river itself has had its course determined along the base of the scarp. A displacement of from 300 to 600 feet is commonly shown.

Gage-Stockton mountain fault. As shown on the map by the heavy broken line, a prominent fault is thought to extend along the eastern bases of Mill, Stockton, and Gage mountains and southward to The Glen. The principal evidences for faulting here are the arrangement of the high, steep mountains along a regular line and the long, smooth contact between the areas of Grenville and mixed gneisses and the igneous rocks. The usual tilted character of the fault blocks is here not shown. Shear zones were not noted though this is of little significance because exposures on the line of the fault are very scarce. The displacement of this fault appears to be as much as 800 or 1000 feet.

If this fault is actually present, then the large wedge of Grenville and mixed gneisses in the valley bottom is of the nature of a through fault block.

Oven-Mill mountain faults. These faults are most likely parts of the same line of fracture, though the connection has not been positively traced. In each case Grenville (chiefly limestone) dips eastward and directly against the base of the mountain. The Oven mountain fault scarp, which rises nearly 900 feet and is very steep to almost precipitous, is an impressive sight as viewed from the west. An eastward downtilt of the block is fairly well shown. The Mill mountain scarp is not so steep but rises to a height of over 700 feet. Because of the much weaker Grenville between the two mountains, no distinct fault scarp is there present.

North Creek fault and branch. This prominent fault strikes north-northeast by south-southwest and passes through the village of North Creek. Northward from the village it is very clearly traceable as a topographic feature for at least 10 or 12 miles and well into the Schroon lake quadrangle along the west side of the

Digitized by Google

Plate 10

W. J. Miller, photo

View across the Hudson river from a point just south of the railroad station at Riverside, and typical of the region through which the river flows. The mountain consists of quartz-syenite. The Glen-Riparius fault, which the river follows for some miles, lies along the base of this mountain.

Digitized by Google

Digitized by Google

valley of Minerva stream. From North Creek to the map edge the line of the fault is marked by a distinct depression which has been formed along the belt of weakness. Except near the Hudson river where the weak Grenville is crossed by the fault, a well-defined fault scarp forms the upthrow side on the west and it is important to note that this scarp strikes at a high angle across the foliation of the rocks, thus proving the independence of the fault and foliation planes. One and one-fourth miles north of North Creek decomposed and somewhat crushed granite marks the passage of the fault. Just at the map edge the eastern face of the Moxham mountain mass is a fine illustration of a steep fault scarp rising to a height of 900 feet. Since the fault here passes through a great mass of rather homogeneous, igneous rock, it is certain that the amount of displacement is not less than 1000 feet. An interesting feature is the large inclusion of Grenville gneiss just south of Moxham mountain; it occupies such an unusual position because it lies on the upthrow side of the fault in a place fairly well protected from erosion.

In the stone quarry just east of the main fault and near the map edge, a fault plane with breccia is clearly exposed in both walls of the quarry. Its strike is north 30° east and it appears to be a minor fracture parallel to the larger one.

At the map edge a fault branches off the main line of fracture and follows the steep mountain side to Fuller pond. Just east of the pond the scarp of Grenville gneiss rises almost vertically for several hundred feet.

South of the village the North Creek fault is clearly traceable by the steep mountain sides of igneous rock against which the Grenville comes in contact along a straight or at least very regular line as far south as Baker's Mills (Thirteenth Lake sheet).

Holcombville fault. There is considerable evidence for a fault with a northwest-southeast strike along a nearly straight line passing through the village of Holcombville. It is represented by a broken line on the map because its presence is not regarded as conclusive. It is thought to extend for some miles into the Thirteenth Lake quadrangle or nearly to the village of North River. The chief evidences for faulting are the long, straight contacts of the Grenville against the bases of the high Oven mountain mass of igneous rock and the great mass of syenite within the Thirteenth Lake sheet. No shear zones were noted and the usual steep scarp and the tilted character of the fault block are absent.

Digitized by Google

Collins brook fault. The Collins brook fault lies nearly parallel to the Holcombville fault and it is named from the small brook which follows the base of the scarp near its north end. It is clearly marked by the topography for a distance of 5 miles between the Hudson river and Mill creek near Wevertown. The evidence for its existence is threefold, namely: (1) the long, regular scarp of granite whose crest is lined with peaks rising from 300 to 600 feet above the base of the scarp; (2) the long, smooth contact of the Grenville against the base of the scarp; and (3) the distinctly eastward downslope of the earth block away from the crest of the scarp.

Henderson mountain faults. The principal fault of this group strikes northeast-southwest along the western base of the Henderson mountain mass. Its position is plainly marked by the topography, and though the scarp is not as steep as usual, it is nevertheless very prominent and straight and cuts across the foliation of the rocks at a high angle. The sharp swing of the Hudson river northeastward for 1½ miles along the line of the fault has been determined by the crushed belt of weakness. North of the river the position of the stream which flows through Bird pond has also been determined by the fault. As judged by the height of the scarp at the south end and also at the base of Henderson mountain, the displacement is fully 700 feet. Where the fault crosses the belt of mixed gneisses the scarp is much less prominent because of the relative weakness of the rocks there. No tilting of this fault block is noticeable. This fault certainly continues for some 3 miles northward into the Schroon Lake quadrangle along the western bases of Green and Pine hills.

The second fault of this group strikes almost parallel to the Henderson mountain fault and lies at the eastern foot of the mountain whose elevation is 1915 feet. The very steep side of this mountain rises 700 feet and is another good example of a fault scarp wholly within homogeneous rock. Where the fault passes into the area of weaker mixed gneisses the scarp is much less prominent.

The third fault of this group is a small one which lies south of Igerna and along the north side of the Hudson river. It is wholly within the area of mixed gneisses but at some places almost vertical scarps rise fully 200 feet.

Schroon lake faults. The larger of the two faults here described strikes northeast-southwest and extends along the eastern

Digitized by Google

side of the south end of Schroon lake and thence southward to the north end of Loon lake. At two places along Schroon lake the fairly steep scarp rises fully 400 feet. The southern end of the fault block is a mass of Grenville (chiefly quartzite) whose bold scarp at one place rises 400 feet. The whole fault block, especially the southern part, shows the usual downslope toward the east. This scarp strikes at a high angle across the foliation bands and hence it is difficult to account for except on the basis of faulting.

A smaller fault along the western side of the southern end of Schroon lake has a prominent scarp rising some 300 to 400 feet. Where it cuts across the gabbro stock near the map edge the fault scarp rises as a high vertical wall along which the rock is unusually soft and weathered and evidently sheared.

Loon Lake mountain fault. The short fault shown on the map just east of the north end of Loon lake and at the base of Loon Lake mountain is one of special interest. Here again the contours are not close enough together since the fault scarp which rises to a height of 700 feet is very steep, the upper 300 or 400 feet being a sheer precipice. We have here at once the highest steep ledge of Grenville and the finest example of a practically unaltered fault cliff within the quadrangle (see plate 10). The upper portion of the cliff consists of quartzite in thin to thick beds with low northeasterly dip so that the truncated edges of the quartzite layers are distinctly visible in the face of the cliff. The less steep scarp forming the western face of this fault block as well as its downtilt toward the east are due to the Schroon lake fault already described. Plate 11 gives a good idea of the appearance of this fault block mountain.

Other faults. The small fault north of Valentine pond strikes due north and south and shows a prominent scarp near its north end. The contours are not close enough together on the mountain side since the wall of rock, which rises fully 600 feet, is very steep to actually vertical in places. Hard, distinctly banded Grenville gneiss makes up the upper three-fourths of the wall and rests upon granite. The fault has broken sharply across the strike of the foliation of both the Grenville and granite.

As judged wholly by the topography, there appears to be a considerable fault block just west of Loon lake. The fault and its scarp lie from 1 to 1½ miles west of the lake and the downtilt toward the lake is very noticeable.

The shape of the lake basin and character of the topography suggest the presence of a fault along the west side of Friends lake.

Digitized by Google

As shown on the map, short faults are suggested at the eastern base of Mill mountain, the western base of Stockton mountain, and the northern base of Wolf pond mountain. Except for some evidence of shearing on the side of Stockton mountain, the only evidence for these faults is topographic, it being difficult to account for these steep scarps except on the basis of faulting.

The writer believes it quite likely that other, chiefly minor, faults occur within the quadrangle, but the ones above described are the only ones he feels justified in representing on the geologic map as actually or very probably present.

FOLIATION

All the rocks except the diabase and pegmatite show more or less of the foliated structure. It is best seen in the Grenville gneisses which are commonly distinctly banded due to differences in the composition of the beds, the foliation so far as observed always being parallel to the bedding. The syenite, granite, and granite porphyry are always gneissoid but never distinctly banded, the structure being accentuated by a drawing or flattening out of the dark colored minerals parallel to the foliation. The more basic pyroxene and hornblende syenites are, as a rule, not very gneissoid, as, for example, the Bull Rock mountain syenite. In fact it may be stated as a very general rule that the more basic, even and medium grained rocks of the syenite-granite series are least gneissoid; while the more acid rocks carrying hornblende and some biotite are clearly gneissoid; and the most acid rocks rich in quartz and biotite are very gneissoid. In these last named rocks the very presence of biotite flakes and the tendency of the quartz to become flattened favor the development of the foliated structure. Again, it often happens that when members of the great intrusive series, especially the granites, are close to the Grenville the rocks are more gneissoid. Thus, at the top of Heath mountain the pink granite is rather poorly gneissoid while at the base of the mountain it is very gneissoid.

The typical basic gabbro stocks seldom show a gneissoid structure except rather often in the narrow amphibolite borders. Some of the more acid stocks are clearly gneissoid.

An interesting feature is the common occurrence of rapid changes in degree of foliation even within the same rock ledge. Thus, just west of The Glen (on the mountain side) there are big ledges of

Digitized by Google

Plate 11

W. J. Miller, photo

The Loon Lake mountain fault-block, as viewed from a point three-fourths of a mile to the south-southwest. On the left (west) side the steep slope is that scarp of the larger of the two Schroon lake faults. The down-tilt of the block toward the east is perfectly shown. The cliff, several hundred feet high, which faces the south, is the scarp of the fault along the south side of the mountain. The upper portion of this mountain, which rises 600 feet above the valley, consists of Grenville quartzite and its lower portion of biotite-garnet gneiss.

Digitized by Google

Digitized by Google

hornblende granite. At times the rock is pinkish gray, medium to coarse grained, and not very gneissoid; while again, and by rapid changes, the rock is gray, fine grained, and very gneissoid to almost schistose. Both rock types have the same composition and both show signs of granulation, but the latter rock especially so. One of these clearly does not cut the other, but rather there is a rapid gradation from one to the other parallel to the foliation, and it seems clear that the fine grained, very gneissoid rocks were produced along belts of shearing perhaps at the time of the development of the foliation. Such a rapid transition from fine to medium grained granite is also well shown even in a hand specimen from the summit of Oven mountain.

Many dip and strike observations on the foliation were made, the more representative ones being plotted on the accompanying map. Strike observations can generally be made with a fair degree of accuracy, but dips can seldom be determined to nearer than 5 or 10 degrees. The amount of dip is usually rather moderate, most often ranging from 30 to 60 degrees. Considered as a whole, the prevailing strike of the foliation ranges from north and south to northwest and southeast with dips almost uniformly toward the east. The northern central portion is exceptional with its east and west strike and northward dip. Also there are important departures from the prevailing direction of dip and strike in certain Grenville areas as south of Johnsburg, south of Thurman, and between Pottersville and Starbuckville, in which areas the directions are very variable. On the Long lake sheet, according to Professor Cushing, the foliation is more erratic in the eruptives than in the Grenville, but here precisely the reverse is true.

FOLDING

Before any important general statements can be made regarding the character of the folding, a wider area will have to be studied. A striking feature is the almost uniform eastward to northeastward dip of the foliation, which suggests the possibility of isoclinal folding but aside from this uniform direction of dip, there is much evidence against such isoclinal folding. The generally moderate angles of dip; the perfect agreement of foliation and bedding planes even where the strikes and dips are erratic; and the utter lack of any evidence for repetition of the strata even in long sections like that of figure 1 are strong points against isoclinal folding. Professors Cushing and Kemp recently stated

Digitized by Google

with reference to the Long Lake and Port Henry-Elizabethtown quadrangles that the Precambric rocks show no good evidence of having been more than moderately folded or tilted, and this appears to be true of the North Creek quadrangle as well.

Locally, the limestone and accompanying pyroxene gneiss may be intensely contorted or twisted, probably being due to the more plastic character of the limestone when subjected to great pressure. The pyroxenic bands are often pulled apart into small lens-like masses as shown in plate 11 and figure 9. Other fine cases of contorted limestone may be seen at the river bridge near Thurman station (off the map); just north of the Ferry at the river's edge (see plate 3); along the road 1¼ miles southwest of Kelm pond; and along the road a little east of north of County House mountain.

Figure 9 represents a sketch, drawn to scale, of a mass of limestone on the south side of Crane mountain which has been contorted and forced for 20 feet across the foliation bands of the associated hornblende-garnet gneiss.

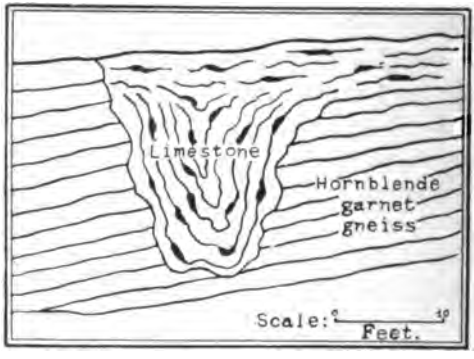


Fig. 9 Sketch showing a peculiar arrangement of Grenville rocks as seen by the roadside on the south side of Crane mountain and three-fifths of a mile from the summit of the mountain. The limestone has been contorted and forced across the foliation bands of the associated gneiss. The black patches represent drawnout fragments of pyroxenic gneiss.

SURFACE OF THE GREAT SYENITE-GRANITE INTRUSIVE MASS

The very ancient Grenville strata were invaded by a vast mass of molten syenite and granite which, in part, pushed aside or upward or engulfed some of the Grenville and, in part, left patches of greater or lesser extent practically intact. This has largely given rise to the very decided "patchwork" appearance of the geologic map.

Digitized by Google

Plate 12

W. J. Miller, photo

Contorted Grenville limestone as seen near the road one and one-half miles southeast of Johnsburg. The darker streaks are pyroxenic bands which have been badly twisted and drawn out.

Digitized by Google

Digitized by Google

The sharpness of the contact between the igneous rocks and the Grenville and the altitude of the igneous masses above the Grenville have often been accentuated by the faulting, but in spite of this some idea of the irregular surface of the great intrusive mass may be gained. Thus, the Grenville between Kelm and County House mountains occupies a depression fully 300 or 400 feet deep in the granite porphyry; while between Mill and Oven mountains the Grenville occupies a depression some 700 or 800 feet deep in the granite. Even if we grant the possibility of some faulting of the Pine-Gage mountain mass, it seems clear that this igneous rock rose by intrusion some hundreds of feet through the Grenville. In spite of the accentuated heights of the igneous masses of Hackensack, Moon, Heath, Potter, Huckleberry, and Crane mountains, it seems necessary to regard a considerable amount of the elevation of the igneous rocks above the Grenville as due to the intrusion itself. The only other alternative is the untenable view that faults completely surround these igneous bodies.

In general, then, we see that the great intrusive body often shows irregularities on its surface which vary in altitude by hundreds of feet within from 1 to 3 or 4 miles.

TOPOGRAPHY

RELATION OF TOPOGRAPHY TO ROCK CHARACTER

The surface configuration of the North Creek sheet is almost perfectly adjusted to rock character. A glance at the geologic map will show that the Grenville rocks, with few exceptions, occupy the lowlands; this is because of the relative weakness of those rocks as compared with the intrusives. The limestone areas or belts, being weakest of all, are invariably found in the valleys, and stream courses have commonly developed along such belts. Occasionally the more resistant Grenville gneisses, even where unaffected by faulting, have stood out fairly well against erosion as, for example, south of Valentine pond and south-southwest of Thurman. The Grenville quartzite being quite pure and very resistant usually stands out fairly conspicuously in the Grenville areas. This is well shown in the area south of Warner pond, though the height is there accentuated by faulting. The steep slope of the quartzite ridge east of Tripp pond appears to be due to more rapid wearing away of the much weaker underlying Grenville. In the mixed gneiss areas, particularly where the Grenville is abundant, the topographic development has been very similar to that of the Grenville areas.

Digitized by Google

The igneous rocks, where homogeneous and free from Grenville inclusions, without exception form the highest mountain masses. Occasionally the gabbro bosses appear to be slightly more resistant than the country rock and they then form the tops of low mountains or hills.

Another topographic feature often locally conspicuous is the sand flat or flat-topped sand terrace. Among the best examples are: in the vicinity of Warrensburg and Pottersville, west of Starbuckville, southwest of North Creek, and at a number of places southwest of Johnsburg. These represent delta deposits which were formed in glacial lakes which will be described in the succeeding pages.

RELATION OF TOPOGRAPHY TO ROCK STRUCTURES

Some of the most prominent topographic features of the quadrangle are the bold escarpments, more or less well-defined ridges, and isolated mountain masses or domes of igneous rock. These rock domes will be especially treated under the next heading. Most of the escarpments or ridges are due to faulting and have already been described. Some ridges, however, especially those in the Grenville areas, are due to other structural features combined with rock character. Thus the prominent ridge of gneiss which runs several miles southeastward from North Creek is due to the fact that a belt of weak limestone everywhere dips sharply under the harder rock of the ridge. The ridge south of Valentine pond is to be explained in a similar manner. Many small streams in the Grenville have developed along structural belts of weakness.

In the igneous rocks, too, there is a notable tendency for local short ridges and valleys to develop along lines parallel to the direction of foliation.

The most remarkable topographic feature in the whole region is the deep, narrow rift between Crane and Huckleberry mountains, which is certainly due to a combination of faulting, a belt of weak Grenville, and some erosion since the faulting.

EXFOLIATION DOMES [1]

One of the most striking features of the landscape, especially in the southern two-thirds of the quadrangle, is the prevalence of distinct, isolated, domelike, topographic forms which rise hundreds

[1] For a fuller discussion of this subject, see paper by the writer in N. Y. State Mus. Bul. 149, p. 187–94.

Digitized by Google

Plate 13

W. J. Miller, photo

Mill mountain, as seen from a point three-fourths of a mile to the southwest. This is a perfectly isolated dome of gray to pinkish-gray granite which rises fully 700 feet above the surrounding country.

Digitized by Google

Digitized by Google

W. J. Miller, photo

Potter mountain, four miles west-northwest of Warrensburgh, as viewed from a point one mile south-southwest. Quartz-syenite makes up the mountain mass, while Grenville limestone underlies the valley in the foreground. This mountain is a fine example of the exfoliation domes which are so common within the quadrangle. The dome rises 700 feet above the valley.

Digitized by Google

Digitized by Google

of feet above the comparatively lowland of the region. A comparison of the North Creek sheet with all other published Adirondack maps shows that, from the physiographic standpoint, this region is noticeably different from the Adirondacks in general.

Some of the best examples of such domes are: Kelm, Chase, Tripp, Hackensack, Moon, Heath, Potter, Birch, No. 9, Little, Crane, Huckleberry, Mill, Stockton, and Prospect mountains. The greatest of these domes is Crane mountain which rises 2000 feet above the immediately surrounding country. The upper 1000 to 1500 feet of this mountain are very steep to almost precipitous on all sides except the north making this great rock dome a grand sight as viewed from Thurman (see plate 8). Mill and Stockton mountains deserve special mention because they rise as two great isolated masses above the comparatively low and featureless surrounding country and form conspicuous features of the landscape as viewed from any of the higher points for a number of miles around (see plate 13). As viewed from the south, Potter mountain is a fine example of a rock dome which rises 700 feet above the general level of the country (see plate 14).

The domes may be classified under three headings according to shape: (1) those with nearly circular bases and which are very symmetrical and almost uniformly steep on all sides, as Potash, Mill, and Stockton mountains and the top of Kelm mountain; (2) those with elliptical bases and represented by nearly concentric elliptical contours to the summit, as Moon, Birch, No. 9, and Huckleberry mountains; and (3) those of irregular shape as shown on a large scale by Crane mountain and many smaller masses.

After climbing all the domes the writer has been impressed by the almost universal occurrence of exfoliation on a large scale over their surfaces. These mountains are literally peeling or shelling off by the removal of exfoliation sheets of great size, some having been noted as much as 50 to 75 feet across and from 1 to 3 feet thick. Among many other good places to observe this phenomenon are on the west or south sides of Moon, Crane, or Huckleberry mountains. Not infrequently, especially during the fall and spring months, slabs loosen up and go thundering down the mountain sides. Though the rocks are all clearly gneissoid, the exfoliation appears entirely to disregard this structure and often great sheets come off at right angles to the foliation.

This very common occurrence of exfoliation domes in the region the writer believes to be due to a combination of factors especially

Digitized by Google

prominent in this part of the Adirondacks. Among these factors are: (1) character and distribution of the rocks whereby small to large masses of hard, homogeneous, igneous rocks have broken through the comparatively weak Grenville strata to produce a sort of "patchwork" effect so that, as a result of long erosion, the hard, igneous masses have stood out prominently above the Grenville: (2) faulting, whereby the "patchwork" effect and steep scarps have been either produced or sharply accentuated; (3) glaciation, whereby the isolated mountains of igneous rock were swept clean of decomposed surface rock and more or less smoothed or rounded off, thus favoring postglacial exfoliation; and (4) temperature changes, humidity etc., whereby the bare slopes of the isolated elevations of crystalline rock, under the conditions of comparatively rapid temperature changes in this the driest part of the State, are favorable for exfoliation.

PENEPLAINS

It is well known, especially as a result of the work of Professor Kemp and, more recently, that of Professor Cushing on the Saratoga sheet and of the writer on the Broadalbin sheet, that the southeastern Adirondack region had been worn down to the condition of a fairly good peneplain immediately prior to the advance of the upper Cambric (Potsdam) sea. Altitudes above the general peneplain level were not over a few hundred feet at the most. This conclusion has been reached through a study of those places along the borders of the Adirondacks where the Paleozoic rocks directly overlie the Precambrics. The position of the North Creek quadrangle renders it practically certain that this very ancient (Cambric) peneplain extended over its area, but because of the extensive faulting and erosion of the region, that old peneplain surface is nowhere certainly recognizable.

Again, it is well known that, by the close of the Mesozoic era, a fairly well-developed peneplain condition had once more been produced over this region in common with southern New England, New York, and the northern Appalachians. Professor Davis has shown [1] that the Berkshire hills area, during the late Mesozoic, had been worn down to a fairly good peneplain with occasional low mountains (monadnocks) rising above the general level. There is strong reason to believe that a similar condition prevailed over the southeastern Adirondack region, but with the monadnock

[1] Physical Geography of Southern New England in Physiography of the United States.

Digitized by Google

feature probably even more prominent. The comparatively even sky line of the western Adirondacks together with the high plateau called Tug Hill just west of the Black River valley, practically prove the former peneplain condition of that portion of the Adirondacks. This peneplain is known to have been elevated late in the Cretacic period or the early Tertiary period and, as already stated, much of the faulting of the eastern Adirondacks occurred at the time of that great uplift or even later. Thus the fact that this peneplain had considerable irregularities on its surface, combined with the facts of excessive tilting of the earth blocks by faulting and subsequent erosion, have quite effectually masked even this later peneplain surface. Doctor Ogilvie says with reference to the Paradox lake quadrangle,[1] that the even sky line of some of the mountains suggests an uplifted peneplain, and also that the long, smooth, eastward slopes of the fault blocks probably represent portions of the peneplain surface which were produced before the faulting. Similar evidences occur within the North Creek quadrangle as, for example, the rather even sky lines of the Henderson, Pine-Gage, Huckleberry, and Chase mountain masses, and the numerous eastward-sloping fault blocks already described. Anything like accurate knowledge of the character of this Mesozoic peneplain within the map limits is, however, lacking.

GLACIAL AND POSTGLACIAL GEOLOGY

CHANGES OF LEVEL

It is important to recall the well-known fact that the eastern portion of North America, including the Adirondack region, immediately preceding and doubtless during a good part of the Glacial epoch was notably higher than it is today. The submerged channels of the lower Hudson and St Lawrence rivers prove that the land there must have been something more than 1000 feet higher than now in order to have allowed the channel cutting. Toward the closing stages of the Ice age, and directly after it, there was a submergence of the whole region to below the present level as shown by the so-called raised beaches or delta deposits in the Hudson and Champlain valleys. In the Champlain valley the deposits are chiefly clays which were formed in an arm of the sea as proved by the presence of marine fossils. These deposits are now several hundred feet above sea level in the Champlain valley, which proves

[1] N. Y. State Mus. Bul. 96, p. 468.

Digitized by Google

at once that during the time of maximum subsidence the region stood several hundred feet lower than now, and that the most recent land movement has been one of elevation which has brought the marine deposits to their present position several hundred feet above sea level. This last (upward) movement has a direct bearing upon the glacial lake deposits of the North Creek quadrangle, and it is important to note that this upward movement was differential with greatest uplift toward the north. Using the figures of Professor Woodworth, the greater uplift of the land toward the north, passing along the southern part of the Champlain valley, has amounted to about 3½ feet a mile.[1] Practically this same figure may be applied to the North Creek area since it is so close to the southern end of the Champlain valley.

DIRECTION OF ICE FLOW

The evidence is conclusive that the North Creek quadrangle was vigorously glaciated. Many widely distributed glacial striae — sixty in all — have been observed within the map limits and are all recorded on the geologic map. Such a large number of striae is very unusual, certainly being far greater than for any other quadrangle so far mapped in the eastern, central, or southern Adirondacks. As usual the striae are most frequently seen along the highways in the valleys and on ledges from which the glacial drift covering has recently been removed. A number of striae have been found away from the roads and even on mountain sides, but never on mountain tops because where exposed on the bare ledges they have been obliterated by postglacial weathering.

Of the sixty recorded striae, the extreme range in direction is only from south 20° east to south 20° west, with the north-south direction nearly an average. In fact many of the striae do run north-south and very few vary more than 10° either side of this. The direction of ice movement indicated by these striae is exceptional for the central and eastern Adirondacks as judged by observations made on the Long lake, Paradox lake, and Elizabethtown-Port Henry sheets over which areas the general movement was southwestward at the time of maximum glaciation. The reason for the southward movement over the North Creek sheet is not an easy thing to account for, though it may possibly have been due to a crowding of the ice into the Hudson valley and a local deflection of the general southwesterly current where the ice flowed

[1] N. Y. State Mus. Bul. 84, p. 206, 228 and plate 28.

Digitized by Google

against the much higher mountains which are arranged along the eastern side of the adjoining Thirteenth Lake sheet.

Some of the striae are so situated in valleys as to suggest that, locally at least, the ice currents followed the valleys, but many others are situated wholly without reference to the topography. Among the best examples of striae which are significant as proving that the general ice movement was irrespective of even the major topographic features are the following: just north of Mud pond and immediately south of the Huckleberry-Crane-Little mountain masses, thus showing the retention of the southward course in spite of those mountains; immediately under the steep fault scarp on the east side of Loon lake; at the north bases of Pine and Gage mountains, showing that the ice current headed straight for those high mountains; and on the hilltop just northwest of Johnsburg where the ice left its record after having plowed diagonally up the hill for an altitude of several hundred feet instead of following the valley.

The great depth of ice over the region is proved by the frequent occurrence of drift boulders even on the high mountains, the high altitudes of some of the striae, and the glacial lake on Crane mountain. Some of the striae at considerable altitudes are as follows: north of Mud pond (southwest corner) at nearly 2000 feet; 2 miles east of Cherry ridge at from 1500 to 1600 feet; west base of No. 9 mountain at 1600 feet; 2½ miles southwest of Johnsburg; at 1550 feet; on the side of Stockton mountain at over 1500 feet; and one-half of a mile northwest of Johnsburg on a hilltop at 1480 feet. On this basis, granting a fairly level ice surface, the depth of ice must have been at least 1000 feet or the difference between these highest striae and the Hudson river to the east. However, the presence of the glacial lake with drift dam well up on Crane mountain, and at an altitude of 2620 feet, shows that the ice was deep enough to cover the mountain that high up at least. According to this the ice must have been at least 1500 feet deep in the valley just north of Thurman and fully 2000 feet deep in the valley of the Hudson river.

ICE EROSION

To say the least, ice erosion was very effective in the removal of nearly all preglacial soils, decomposed rock, and loose joint blocks. The mountains were swept clean of such materials and left standing as more or less rounded off bare rock ledges, while during

Digitized by Google

the retreat of the great ice sheet the valleys were partially filled with drift deposits. Decomposed rock material of preglacial age can now be seen at very few localities and those in specially sheltered places on steep south slopes where ice erosion was very ineffective. One such place is along the road 1 mile east-northeast of Wevertown at the south base of the mountain where the granite is decomposed, and another is just west of Crane mountain where the south side of a ridge of hornblende gneiss is badly decomposed to a reddish brown color.

Where favorably situated with reference to the direction of ice flow, the fault scarps were freshened up chiefly by the removal of the heavy talus slopes. An especially noteworthy example is the steep scarp 1⅓ miles north of Valentine pond where, on the nearly vertical wall of rock, good glacial striae may be seen. Heavy talus deposits which were not favorably situated for removal by ice erosion occur at the base of the Loon lake mountain scarp on the south side, and also at the base of the scarp next to the south.

There is good evidence for vigorous ice erosion in the valleys in the southeastern portion of the quadrangle, some of the facts favoring this view being: (1) the abundance of scratched, polished, and rounded rock surfaces; (2) the comparative freshness of the rocks, even in the case of the weak Grenville; (3) the unusual weakness of much of the rock, especially limestone, which occupies the valleys; (4) the fact that these belts of weak rock must have been deeply decomposed during the long preglacial time, thus favoring extensive removal of material; and (5) the north-south movement of the ice being parallel to the Grenville valleys and hence being favorable for ice erosion because of easy flowage of the deep ice through the valleys. Other Grenville valleys were doubtlessly also similarly lowered by ice erosion.

GLACIAL DEPOSITS

Glacial boulders or erratics are very common over the entire area and, as usual, most of them are of local origin. This fact of local origin was successfully employed to locate certain important outcrops, especially of gabbro or diabase, by tracing the line of boulders to the parent ledge. All sorts of Precambric rocks of the region are represented among the boulders, the granite and syenite naturally being the most common. A type of boulder

Digitized by Google

wholly derived from without the quadrangle, and especially abundant in its northern portion, is the coarse grained anorthosite whose nearest parent ledges are in the northern portion of the Schroon lake sheet. Such boulders several feet across are frequently encountered. The only Paleozoic rock boulders noted were of Potsdam sandstone and, as already stated, these are nearly all confined to the Hudson valley between Heath and Moon mountains.

Glacial till or ground moraine material is quite widespread, especially over the lowlands, but no great thickness was noted at any place. It would seem that more material was scraped off by ice erosion than was deposited as till. As would be expected from the nature of the rocks, the till is always sandy or gravelly and generally filled with boulders. Not a single good example of real boulder clay was observed.

Kames are of uncommon occurrence. Three or four good ones, large enough to be shown by the contour lines, lie in the little valley a mile west of No. 9 mountain. Some other stratified sand and gravel deposits of rather doubtful kame origin occur in the valley between Chestertown and Tripp pond.

But one fairly well-defined boulder moraine came to the writer's notice and this is quite clearly traceable as a belt 1 to 3 miles wide from the vicinty of South Horicon westward around Prospect mountain, thence across the southern part of Loon lake and a mile or so southward, thence over the southern end of the ridge just west of the lake, and nearly to the river. The ice front must have been nearly stationary for some time along this line to allow the accumulation of so many boulders.

GLACIAL LAKES

Glacial Lake Warrensburg. This extinct glacial lake, recently described by the writer, is so named because of the location of the village of Warrensburg upon the old lake deposit which is especially well shown as a sand plain area between the village and the Hudson river. The concordant altitudes of this sand flat, where unaffected by subsequent erosion; the remarkable freedom of the surface from boulders; and the crudely stratified character of the material as shown in cuts all afford conclusive evidence for static water conditions here, the sand plain material having been formed as a delta deposit in the lake. This is a good example of a small pitted sand plain, there being two notable depressions (one con-

Digitized by Google

taining a pond) below the level of the plain. Such depressions are thought to be due either to unequal deposition of the delta material or the presence of large buried blocks of ice which on melting would leave the depressions. The contact of the lake surface, at its height, with the surrounding land is quite accurately indicated by the 760 foot contour line but, because of postglacial changes of level, the actual altitude of the lake above the sea is not known. On a line passing east and west through Warrensburg the main body of water showed its greatest width of about 3 miles. Clearly defined sand terraces, the highest of which always rise to the 760 or 780 foot contour lines, prove that important arms of the lake extended fully 9 miles up the Schroon river valley above Warrensburg; nearly 4 miles up the Hudson valley above the mouth of the Schroon; and at least 2 miles down the Hudson from the mouth of the Schroon. The altitudes of these sand terraces gradually increase slightly toward the north because of the postglacial warping of the region as explained on page 66.

In the vicinity of Warrensburg, and especially along the Schroon river, the lake deposits, though deeply trenched, have seldom been cut through to the underlying rock. As a result of the meandering of the Hudson and Schroon rivers, during the process of trenching the old lake deposits, fine terraces have been developed. Such terraces are particularly well shown between Potter, Heath, and Moon mountains where they are at two or three different levels and from a quarter to a half mile back from the river as the contour lines partly indicate.

The cause of the standing water was a blockade, probably of glacial drift, in the Stony Creek gorge (Luzerne sheet).

Glacial Lake Pottersville. This lake, here described for the first time, must take rank as one of the largest and most interesting extinct glacial lakes yet recognized in the Adirondacks. It is so named because the best example of sand flat delta deposit formed in the lake lies in the vicinity of Pottersville. This sand plain covers fully a square mile at an altitude of about 800 feet, though the highest waterlaid sands and gravels occur from one-third to two-thirds of a mile northwest of the village and at an altitude of nearly 900 feet. This material was all formed as a delta deposit by Trout brook in a body of water which stood at a level corresponding approximately to the present 900 foot contour line at Pottersville. This body of water was Lake Pottersville of which Schroon lake is only a shrunken remnant. The

Digitized by Google

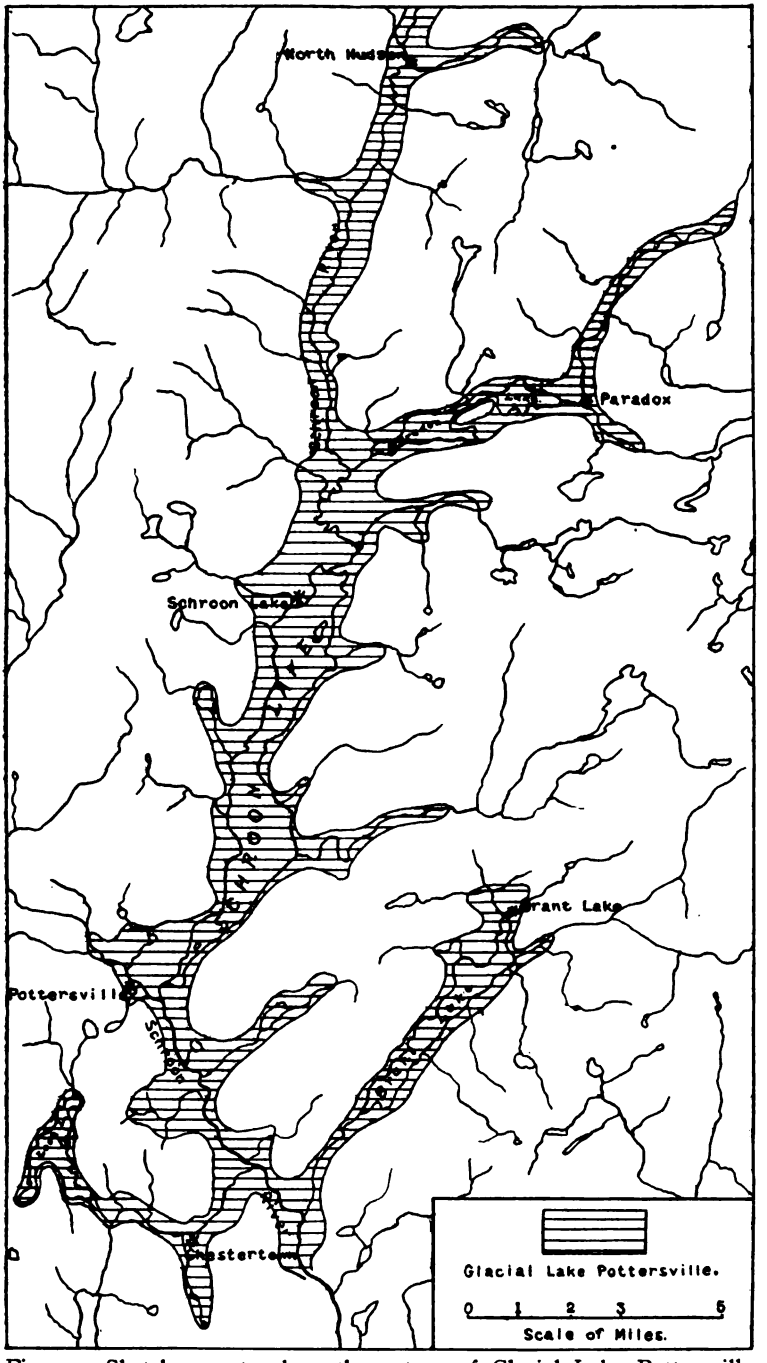


Fig. 10 Sketch map to show the extent of Glacial Lake Pottersville

Digitized by Google

existence of many sand flat delta or lake deposits makes it practically certain that this was a very extensive lake. It extended northward up the Schroon river as a long, narrow body of water at least as far as North Hudson, with a branch extending eastward to form an enlarged Paradox lake. Southward from Pottersville, all the lowland (below the 880 foot contour) southward to South Horicon and Meade pond (south of Chestertown) was occupied by the lake, with a prominent branch extending northeastward over the Brant lake area, and a smaller branch over Valentine pond. Another branch appears to have reached northwestward from Chestertown over the Loon lake area, though this is not quite so certain. The dam which held this water at so high a level was quite certainly one of glacial drift across what is now the deep, narrow channel of Schroon river 1 mile south of South Horicon. It is important to note in this connection that the boulder moraine, above described, crosses the river here. The Schroon lake reservoir, which may some day be built by the State by means of an artificial dam across the river at this same point, would largely restore the former lake.

Sand terraces around Brant lake, especially toward the east end along Mill brook, prove the former higher water level of that lake. Around Loon lake there are suggestions of lake deposits about 10 or 15 feet above the present water level but they are not very decisive. In the immediate vicinity of Chestertown and one-half of a mile west of Starbuckville, there are waterlaid sands or sand flats reaching altitudes of about 880 feet as nearly as can be judged from the contour lines. At Pottersville the delta material lies at from 880 to 900 feet; north of Schroon lake village up to 920 feet; and at North Hudson (Paradox lake sheet) up to 960 feet. Between Schroon lake village and North Hudson there is an almost continuous succession of such terraces along Schroon river, with gradually increasing altitudes toward the north. The rate of increasing northward elevation of these old lake delta deposits is in almost perfect harmony with the figures given by Professor Woodworth for the warping of the Lake Champlain terraces. As stated on page 66, the rate of northward increase at the latitude of Schroon lake should be about 3½ feet a mile. The altitude of the terraces at Chestertown is 880 feet; at Schroon Lake village 920 feet; and at North Hudson 960 feet. This is a total difference in altitude of 80 feet in the distance of 22 miles from Chestertown to North Hudson, or at the rate of 3.6+ feet

Digitized by Google

a mile, which is very close to the figure given by Woodworth for the lower Champlain valley.

Glacial Lake Johnsburg. This was a small irregular shaped lake extending for about 2½ miles southwestward from Johnsburg as proved by a number of well-distributed sand flats or terraces at, or a little above, the 1300 foot contour line which approximately marks the old shore line. The best terraces, practically unrepresented on the contour map, are : two-thirds of a mile west, three-quarters of a mile southwest, three-quarters of a mile south-southwest, and at several places about 2 miles south-southwest of Johnsburg.

The cause of this static water condition appears to have been either an ice or glacial drift dam across the Mill creek channel at or not far east of Johnsburg.

Glacial Lake North Creek. The former presence of a lake in the vicinity of North Creek is proved by the existence of thick stratified sands, comprising terraces and flats. South of the village the sands show a depth of over 100 feet where they have been trenched by the small creek. Holcombville lies on a sand flat at 1160 feet, and the tongue of sand just southwest of North Creek rises to nearly the same altitude. Just north of the river the sands were, no doubt, largely removed by postglacial stream work. From 1½ to 2 miles north-northeast of North Creek (along the new State road) there are stratified sands and gravels running up as high as 1140 or possibly 1160 feet, and these seem to correlate with the deposits south of the village. The precise location of the retaining dam of this lake can not be given but it was either ice or drift, probably the latter, across the Hudson channel not over 2 miles east of North Creek.

One-half of a mile due east of Holcombville there is a small but finely developed flat-topped sand terrace at an altitude of 1240 feet. It extends out as a distinct apron from the mountain side of syenite. The depth of sand in this terrace is fully 200 feet, and it was probably formed in a small, marginal, high level lake when the ice was still present.

The Glen glacial lake. This body of water extended from near the headwater of Millington brook northwestward to the Hudson river, thence along the river channel past The Glen, and to near the mouth of Mill creek. Sand flats at an altitude of 800 feet or

Digitized by Google

a little over, are well shown from 1 to 1½ miles east of the mouth of Millington brook, and a perfect sand terrace, fully 200 yards wide, three-quarters of a mile long, and at an altitude of about 800 feet, lies against a granite ridge two-thirds of a mile northeast of the mouth of the brook. One-half of a mile above the mouth of Potter brook, and also nearly 2 miles above its mouth, are perfect, small sand terraces at from 800 to 820 feet. At The Glen the railroad passes along the base of a fine flat-topped terrace which rises over 60 feet above the track. It is not shown on the map but by lock level its altitude was found to be a little over 800 feet. From 1 to 2 miles north of The Glen and on the east side of the river there is an extensive sand and gravel flat whose altitude is about 820 feet.

It is interesting to note that the coarsest deposits are toward the north because there the Hudson river with its load of debris entered the lake. The deposits of this extinct lake also rise gradually toward the north because of the postglacial land tilting. Near The Glen the lake was very narrow. The water of this lake appears to have been ponded by a drift dam across the Hudson river just below the mouth of Millington brook.

Other extinct lakes. Many other smaller glacial lakes, now either wholly or partly extinct, occur within the map limits. Thus Tripp pond was formerly much larger as shown by a number of fine flat-topped sand terraces lying at from 1020 to 1040 feet. The former lake was over 2 miles long with a drift dam a little over a mile north of the present lake.

The little valley shown on the map 2 miles southeast of Chestertown is certainly an old lake bottom. Most of the swamp areas are also old lake or pond bottoms.

Existing lakes. None of the lakes of the quadrangle are of preglacial origin. Some of them, such as Schroon lake, Valentine pond, Tripp pond, Smith pond, and probably Loon lake, are merely shrunken remnants of former larger bodies of water as already described. The waters of all the lakes and ponds are held in either by glacial drift or old lake deposit dams and most of them show evidence of having been at more or less higher levels. Some of the ponds seem to occupy depressions in the irregularly deposited drift. Ice erosion may have been effective in deepening some of the basins as, for example, that of Friends lake, though positive proof is wholly lacking.

Digitized by Google

POSTGLACIAL DRAINAGE CHANGES

Aside from the destruction or partial destruction of glacial lakes by cutting down the outlets or filling them up or both, and the moderate amount of downcutting by the larger streams with resulting development of terraces, there appear to have been no important drainage changes. Due to the irregular distribution of the glacial drift many of the small streams have postglacial courses, but the larger streams, like the Hudson and Schroon rivers, are believed to follow practically their preglacial channels which are well adjusted to the character and structures of the rock masses over which they flow.

In a recent paper [1] the writer discussed certain important postglacial drainage changes in the southeastern Adirondacks, and since one of the changes concerns the Hudson river immediately after it leaves the North Creek sheet, a very brief statement will here be made.

Instead of the present long, circuitous course of the Hudson river past Stony Creek, Luzerne, Corinth, and thence across the Luzerne mountain to Glens Falls, the preglacial Hudson certainly took a shorter course, most likely through the channel from Warrensburg to Caldwell and thence to Glens Falls.

The great gorge of the Hudson above Stony Creek station is surely of either interglacial or postglacial origin and in its stead a preglacial divide was located there. Evidences favoring this view are given in the paper above cited.

Since the preglacial Hudson river did not flow southward across the Luzerne sheet, it must have flowed eastward across the low mountain ridge between Warrensburg and the Lake George depression. There are but two possible channels there, namely: the Warrensburg-Hillview channel and the Warrensburg-Caldwell channel. In the paper above cited, arguments are presented to show that the latter channel was the more likely one. The preglacial Hudson was joined by the Schroon just east of Warrensburg, while a short tributary, having its source on the Stony Creek divide, flowed northward into the Hudson. An important preglacial stream, called the Luzerne river by the writer, had its source on the Stony Creek divide and flowed southward past Luzerne and Corinth and through the broad valley west of Saratoga Springs.

[1] Preglacial Course of the Upper Hudson River, Geol. Soc. Amer. Bul. 1911, 22: 177–86.

Digitized by Google

SUMMARY OF GEOLOGICAL HISTORY

A brief outline of the geological history of the portion of the Adirondacks covered by the North Creek sheet is here given in order to bring together the principal events of that history in the regular order of their occurrence so far as known.

The oldest known records of the region are written in the Grenville rocks which, by their very character and composition, are undoubted metamorphosed sediments. Because of the great thickness and widespread distribution of these strata in New York and Canada, we know they were deposited in an extensive ocean and that the length of time required for this sedimentation must have been at least some millions of years. While it is as yet impossible definitely to classify the Grenville with either the Archean or Algonkian (Proterozoic), the evidence is decidedly against its late Precambric age.

After the deposition of the Grenville sediments, the whole Adirondack region, including the area of the North Creek sheet, was elevated well above sea level. At this time the Grenville strata were probably folded. Great masses of molten rock, now represented by the syenite, granite, and granite porphyry, were intruded just before, during, or after the uplift, the most reasonable view being that the intrusion occurred during the uplift because the same great pressure could well have pushed up the molten masses during the process of elevation. In some cases the Grenville appears to have been pushed upward and to have been largely removed by erosion since; in other cases the Grenville was more or less engulfed by, or involved with, the molten flood as shown by the numerous Grenville inclusions and the areas of mixed gneisses; while in still other cases the Grenville rocks were left practically intact as shown by the large Grenville areas. These intrusives now exposed at the surface were, at the time of their intrusion, deeply buried under a great thickness of overlying rock material. This we know because they are true plutonic rocks which could have cooled only under such conditions. The vast amount of erosion since their intrusion has exposed them.

Following this great period of igneous intrusion there was a time of minor igneous activity when the gabbros, in molten condition, were forced upward into the crust of the earth. Since the gabbros now exposed at the surface are true plutonic rocks they too must have been deeply buried under material which has been removed by erosion.

Digitized by Google

After the intrusions the whole region was subjected to intense compression and metamorphism when the gneissic or foliated structure of all the rocks so far mentioned was developed. This structure is now shown in the rocks at the earth's surface; but, since such a structure can develop only in rock masses which are deeply buried, we know that at the time of the compression the present surface rocks were deeply covered.

The rocks represented by the coarse grained pegmatite dikes of the quadrangle were intruded after this period of intense compression because they lack the gneissic structure, and before the diabase because the latter rock cuts the pegmatite.

The great elevation of the region, above referred to, inaugurated a long period of erosion to be measured by at least some millions of years, and extending into the early Paleozoic era.

After the removal, by erosion, of some thousands of feet of rock materials, the last igneous activity of the region occurred when the molten diabase was forced through narrow fissures in the earth to cool in the form of dikes. The utter lack of metamorphism and the fact that they cut all the other rocks show that this diabase is the youngest of the intrusives. That it must have cooled rather close to the earth's surface is evidenced by the fine grained to even glassy texture.

As a result of the vast erosion, the whole area was worn down to near sea level and presented only a moderate relief. Then a gradual sinking took place when the sea steadily encroached upon the old land from the east, and the early Paleozoic sediments were deposited upon the old land surface. As the nearby outliers show, the first sediment to cover the area of the quadrangle was the upper Cambric (Potsdam) sandstone, followed in turn by the Theresa passage beds and the Little Falls dolomite which are also of Cambric age.

Recent studies have shown that, toward the close of the Cambric, there was a gentle upward movement of the Adirondack region to above sea level after which some erosion took place. Then, early in the Ordovicic period, the Champlain and Mohawk valley regions sank below the ocean surface when the thick limestones and shales of that period were laid down. It is highly probable that the North Creek area was also submerged under the Ordovicic sea, though positive evidence is lacking. At any rate we have no reason to think that this area, or in fact any of the Adirondack region outside of the immediate Champlain and St Lawrence valleys, was ever again below sea level after the Ordovicic period.

Digitized by Google

Thus it is more than probable that northern New York underwent erosion during all of the late Paleozoic era and certainly during the Mesozoic era, when an immense amount of Paleozoic sediment and some Precambric rock were stripped off by erosion. By the close of the Mesozoic northern New York was reduced to the condition of a fairly good peneplain with some hard rock masses rising to moderate heights above the general level.

At the close of the Mesozoic, or the beginning of the Cenozoic era, the great peneplain was upraised and a new period of active erosion was inaugurated to continue to the present time.

Much of the faulting of the area dates from the time of this peneplain uplift or even later, though it is likely that some dates from toward the close of the Paleozoic era at the time of the great Appalachian revolution.

Immediately preceding and probably during much of the great Ice age this region, like all the northeastern United States, was considerably higher than now as proved by such drowned river channels as those of the lower Hudson and St Lawrence.

During the Ice age of the Quaternary period, the area of the quadrangle, in common with all New York State, was buried under a great ice sheet which has left many records such as striae, glacial boulders, moraines, and drift deposits in general. The preglacial topography was not profoundly altered by ice erosion and deposition. The many extinct and existing lakes of the quadrangle were formed either by the actual presence of the ice dam itself or, more commonly, by irregular deposits of drift across old stream channels.

A subsidence of the land several hundred feet below the present level took place toward the closing stages of the Ice age or immediately after it for this latitude, when arms of the sea extended through the Champlain and St Lawrence valleys.

The most recent movement of the land has been a differential uplift with greater elevation toward the north. At the latitude of the North Creek sheet, this postglacial uplift has amounted to a few hundred feet, the differential character of the uplift being shown by the tilting of certain of the extinct glacial lake deposits.

ECONOMIC GEOLOGY

GARNET

At the time of the field work but one garnet mine was in actual operation within the map limits, but in all there are at least five localities where more or less garnet mining has been carried on as follows: (1) near the top of Oven mountain; (2) one-half

Digitized by Google

of a mile southeast of Holcombville (Rexford's mine); (3) in the mixed gneiss area just south of Daggett pond (Elisha Parker farm); (4) near the mouth of Mill creek (Sanders Brothers mine now in operation); and (5) three-fourths of a mile east of Fuller pond. Besides these the principal garnet mines of the Adirondack region lie in the northern portion of the adjoining Thirteenth lake sheet. One of these is the Rogers (Barton) mine near the top of Gore mountain and the other is the Hooper mine on the west side of Thirteenth lake. In all cases open pit methods of mining are employed.

The Oven mountain mine has not been worked for nearly twenty years, and at no time was a crushing plant operated. After blasting out the garnet-bearing rock and reducing it in size by means of sledge hammers, the large garnets were picked out by hand. The mode of occurrence is of unusual interest. The matrix, or rock carrying the garnets, is a gray, medium grained, feldspar, hornblende, biotite, gneiss, a thin section showing 20 per cent orthoclase; 25 per cent oligoclase to labradorite; 50 per cent hornblende; 2 per cent biotite; 2 per cent magnetite; together with a little pyrite, zoisite, and apatite. Imbedded in this gray matrix are numerous, well-scattered, translucent, pale reddish brown garnets ranging in size up to several inches. These garnets are always quite well granulated and never show crystal outlines. Each garnet is completely inclosed within an envelop of pure, black, medium grained hornblende crystals. Occasionally a half-inch, irregular shaped crystalline mass of acid plagioclase or biotite may lie just between the garnet and the hornblende rim. These reddish garnets completely surrounded by rims of black hornblende, which are in turn imbedded in the gray gneiss matrix, present a very striking appearance. As shown on the geologic map, this garnet-bearing rock occurs as a long, narrow inclusion of Grenville gneiss within the Oven mountain granite.

At the Rexford mine there are several large openings but none have been worked for about fifteen years. The mode of occurrence is almost exactly like that in Oven mountain, only here there appear to be several (smaller) inclusions of the garnet-bearing hornblende gneiss instead of one, and the country rock is a very gneissoid syenite. Garnets up to 5 inches across and always with hornblende rims occur here.

By way of comparison with the Oven mountain and Rexford mines, the Rogers mine on Gore mountain should be mentioned as of exactly the same type of occurrence but with garnets generally

Digitized by Google

much larger, those of 5 or 6 inches in diameter being very common and the largest ones taken out are said to have been nearly the size of a bushel basket. As a rule the hornblende rims increase in width with the size of the garnets, and the large garnets imbedded in the walls of this mine present a most interesting appearance. The garnet-bearing hornblende gneiss here forms an inclusion in syenite fully three-fourths of a mile long and 200 feet wide. Several large openings have been made in this rock.

At the old mine on the Parker farm the rocks are a mixture of granitic syenite and Grenville interbanded parallel to the strike of the foliation. These bands of rock are often 20 to 40 feet wide, one of them being made up of a nearly pure, granular, medium grained mass of irregular crystals of reddish brown garnet and bright green pyroxene (coccolite?). About twenty years ago this band of garnet rock was mined, crushed, and put into barrels, there being no attempt to separate the pyroxene from the garnet.

At the Sanders Brothers mine the mode of occurrence is very similar to that of the Parker mine, the bands of Grenville being, however, somewhat less pronounced and numerous. The rock which is mined is quite badly granulated, and consists mostly of intimately associated reddish brown garnet and green pyroxene (coccolite?) in small grains, with sometimes a little feldspar. There are some streaks or patches of nearly pure garnet. Work began in 1907 on the south side of the creek but now all the mining is confined to the north side (see map). The garnet, pyroxene rock is crushed, put into bags, and shipped to various parts of the world.

Years ago an attempt was made to mine the garnets which occur in the coarse, feldspar, biotite, quartz, garnet (Grenville) gneiss about three-fourths of a mile east of Fuller pond.

At the Hooper mine, near Thirteenth lake, the garnets occur as crystals, often with good crystal boundaries, up to an inch or more in diameter. They are thickly scattered through a medium to fairly coarse-grained, dark to light gray, very gneissoid hornblendic rock which has the composition of a basic syenite or acidic diorite. These garnets never show the rims of hornblende. This type of occurrence has not been noted on a large scale within the map limits of the North Creek sheet, though a rock almost exactly like it does occur at the Rogers mine as a distinct zone (wall rock) intermediate in position and composition between the typical garnet gneiss and the country rock of syenite, where the garnet rock grades perfectly into the syenite.

Digitized by Google

All modes of occurrence of garnets observed by the writer on the North Creek and Thirteenth lake sheets may be summarized as follows: (1) as crystals or grains in various Grenville rocks, as the garnet-pyroxene gneisses, the dark hornblende-garnet gneiss, the gray feldspar-biotite-garnet gneisses or schists, and the white or very light gray feldspar gneisses; (2) as distinct crystals frequently occurring in all types of intrusive rocks — syenite, granite, granite porphyry, and gabbro — except the diabase; (3) as large more or less rounded masses, with distinct hornblende rims, in the long, lenslike inclusions of Grenville hornblende gneiss in syenite or granite; and (4) as more or less distinct crystals, without hornblende rims, in a certain special basic syenitelike or acidic dioritelike rock.

In case no. 1 (for example Sanders Brothers and Parker mines) the garnets have, in the usual way, crystallized out of masses of sediments under conditions of thermal and dynamic metamorphism.

In case no. 2 the garnets appear mostly to have crystallized out of the original magmas, their presence possibly being due to some assimilation of Grenville sediments, though this is by no means proved. Sometimes, as in the gabbros, the garnets may have been produced secondarily after the cooling of the igneous masses.

Case no. 3 (for example, Oven mountain, Rexford, and Rogers mines) is of particular interest because of the very large garnets surrounded by reaction rims. Without question the garnets occur in lenses of Grenville sediment which were caught up or included in the great igneous masses at the time of their intrusion, the tremendous heat and pressure being especially favorable for a very complete rearrangement and crystallization of the masses of sediment which were rather low in silica. The hornblende rims or envelops are quite certainly great reaction rims around the garnets, but just at what stage of the metamorphism they were produced is not at all clear to the writer. The rounded and granulated condition of the garnets suggest that the reaction rims of hornblende may have formed some time after the crystallization of the garnets and possibly at the time when the great pressure producing the foliation was brought to bear.

A clew to the origin of the garnets in case no. 4 (for example, Hooper's mine) is furnished by a study of the wall rock in the mine on Gore mountain. The typical garnet-bearing rock of the mine passes by perfect gradations through an 8 or 10 foot zone

Digitized by Google

into a basic (quartzless) syenite which contains garnet crystals up to an inch or more across but never with hornblende rims, and this rock in turn grades into the typical country rock of syenite which is somewhat garnetiferous. The writer is fully convinced that this transition zone (wall rock) has been formed by the assimilation or actual melting or fusing together of the syenite and the border of the great inclusion at the time of the intrusion of the syenite. In hand specimens and in thin sections, as shown in the field, the garnet rock at the Hooper mine is almost exactly like this wall or transition rock of the Rogers mine and it also appears to grade into the country rock. In the Hooper mine this transition rock makes up practically the whole mass of rock which is mined and is hence much more extensive than at the Rogers mine. All evidence strongly points to the origin of the Hooper mine rock as due to rather thorough melting together of an admixture of syenite and Grenville hornblende gneiss where the Grenville inclusion was perhaps deeper down in the magma and hence subjected to much greater heat, or possibly a number of smaller hornblende gneiss inclusions were assimilated by the molten syenite or granite.

GRAPHITE

Within the map limits but one graphite mine has ever been in actual operation, though prospect holes have been made at various places. The mine, including an open pit and short tunnel and separating mill, is located 1 mile southwest of Johnsburg. The graphite occurs in small flakes in gray, thin to thick bedded, Grenville gneisses which are usually very rich in quartz. A detailed description of specimens from this mine has been given on page 14. Some graphitic limestone was taken out from near the mine entrance. The rocks strike north 70° east and dip 35° to the south. This mine was worked as late as June 1910 but apparently has not been very successful. An interesting feature is a quartz vein up to a foot wide, which cuts across the graphitic beds at a high angle and which contains rich seams (as much as an inch wide) of pure graphite. The mine superintendent stated that in 1899 one piece of graphite weighing 543 pounds was taken out. Excellent specimens of associated quartz and graphite may be obtained from the mine dumps.

A prospect hole 2½ miles due south of Pottersville and close to the road was opened in limestone some years ago. Some of the limestone beds are pyroxenic to serpentinous. The limestone contains occasional flakes of graphite up to one-half of an inch

Digitized by Google

across, as well as some phlogopite, pyrite, brown hornblende, and a few octahedrons of brown spinel.

One-half of a mile beyond the northern map limit and near where the road crosses Trout brook there is an old graphite mine which was not visited by the writer.

Throughout the quadrangle scattering flakes of graphite are rarely absent from the crystalline limestone, and more seldom they are found in other rocks of the sedimentary series.

MICA

The only place where mica mining has been attempted is in a large pegmatite dike, which comes against the long gabbro mass on its east side, 2¾ miles south-southeast of Chestertown. At the time of the writer's visit (1910) the mine was being worked in a small way by two or three men. While occasionally mica is present in considerable quantity, it seldom occurs in books up to 5 or 6 inches across. Muscovite mica is often associated with the pegmatite dikes but thus far no place has been discovered which could really be called a good mining proposition.

ASBESTOS

The only attempt to mine asbestos is at the locality three-fourths of a mile southeast of Thurman village. During the summer of 1910 large prospect holes had been opened up and mining machinery was being installed, though the writer does not know whether the mine is now in operation. The asbestos is of the serpentine variety, known as chrysotile, and occurs in numerous irregular veins in the greenish gray serpentine marble. Of all the veins noted in the prospect holes, the widest was less than an inch, though wider veins may since have been found. The asbestos is of good quality, but numerous fairly thick veins must be found in order to make a paying proposition of the mine.

FELDSPAR

Orthoclase feldspar is of course one of the commonest minerals in the whole region, but only where it occurs in large crystals in the pegmatite dikes is it likely ever to become of commercial importance. In all the numerous pegmatite dikes examined, the orthoclase almost invariably occurs in crystals which are too small and too intimately associated with much quartz and acid plagioclase feldspar to be worth considering as mining propositions. Perhaps

Digitized by Google

the most favorable locality is the pegmatite dike lying along the west side of the gabbro dike on the mountain top 1 mile south-southeast of The Glen. A single mass of pegmatite there is about 25 feet wide and 50 feet long and very rich in orthoclase and albite crystals up to 5 or 6 inches in length, together with more or less quartz and black tourmalin. The nearness to the railroad station and the fact that an old road now extends nearly to the top of the mountain, are features favorable to mining here, but the small size of the exposed mass and the abundance of albite are unfavorable.

ROAD METAL

Rock such as that of the diabase dikes of the quadrangle is popularly known as "trap rock," and it takes rank among the finest natural road building materials because of its hardness, fineness of grain, homogeneity, and good binding power. So far not a single quarry has been opened in any of these dikes though some of them are large and well situated with respect to roads and good quarry drainage. Among such dikes are those at the west base of Heath mountain (Ingraham farm); 1½ miles north-northeast of Pottersville; and two-thirds of a mile a little south of west of Igerna. Smaller, but well located, dikes are three-fourths of a mile southeast of Kelm mountain and one-half of a mile southeast of The Glen.

The gabbro masses, especially the more basic ones, would furnish a very large amount of good road material. This rock is hard, homogeneous and rich in iron-bearing minerals to give good binding power. So far but two quarries have been opened in the gabbros and these for State road purposes. One of these quarries is in the south end of the large, coarse grained, gabbro boss on the south side of Loon lake, and the other is in the gabbro boss 1 mile west of Riverside and near the new State road.

The basic varieties of syenite, especially those free from mica and low in quartz, would also make good road metal, but no quarries have yet been opened in such rock.

The granite and granite porphyry in general are rather poor road materials because of the high quartz and mica content and the usual deficiency of iron-bearing minerals to furnish a good binder. Such rock has, however, been rather extensively quarried at three places for State road work. One of these quarries is situated two-thirds of a mile north of the north end of Loon lake and above the road; the second is along the State road 1¾ miles northeast of

Digitized by Google

Pottersville; while the third is by the State road 3¼ miles north-northeast of North Creek.

The Grenville gneisses are nearly always of poor quality for road work because of the high quartz and mica content and the heterogeneity of the rocks which are in layers of varying composition. In spite of this, one quarry for State road purposes has recently been operated near the southeastern end of Loon lake.

BUILDING STONE

There is an inexhaustible supply of building stone of excellent quality within the map limits. The syenite, granite, and granite porphyry all rank as very strong and durable building stones. Of these the granite porphyry would perhaps make the most effective and beautiful stone when highly polished because of the large, scattering, pink, feldspar crystals which are set in the much finer grained gray matrix. The color of this rock would remain practically unaltered on exposure to the weather. Some of this rock from the quarry at Horicon is said to have been used in the State Capitol at Albany. The pink granites, too, would make beautiful and very durable building stones not subject to color change. The syenites, which are generally greenish gray when fresh, would weather to light brown on exposure to the atmosphere but, as regards durability and strength, they would be excellent stones. These igneous rocks are considerably used locally but because of the distance from population centers, no quarries have been opened up for shipping purposes. The pinkish gray granite used in the construction of the new Warrensburg High School building was obtained from the south side of Hackensack mountain and just off the map.

The only stone which has been quarried for shipping purposes is the green marble or so-called verde antique of the Grenville series. Though occurring at a number of localities, the only place where quarrying has been done, and this years ago, is one-half of a mile west-southwest of Thurman village. This rock is a medium grained, white to greenish gray marble through which are scattered many streaks and blotches of bright green serpentinous material, so that the polished stone presents a striking effect.

Digitized by Google

Digitized by Google

INDEX

Andesine, 40, 42
Apatite, 17, 19, 22, 29, 30, 33, 40, 41
Asbestos, 11, 83
Augite, 29, 30, 31, 33, 40, 41, 42

Baker's Mills, 55
Basaltic glass, 39
Biotite, 11, 12, 13, 14, 17, 18, 19, 20, 21, 22, 25, 28, 29, 30, 31, 33, 37, 38, 40, 41, 42, 58
Biotite-garnet gneiss, 13, 15
Biotite-quartz gneiss, 12
Birch mountain, 46, 48, 50, 63
Bird pond, 56
Brant lake, 72; faults, 53
Building stone, 85
Bull Rock mountain, 18; faults, 52; syenite, 58

Calcite, 12
Carlsbad, 21
Chase mountain, 6, 9, 12, 24, 48, 63, 65; fault, 52
Cherry ridge, 12, 67
Chestertown, 5, 14, 23, 26, 38, 69, 72, 83; faults, 53
Chlorite, 40
Collins brook fault, 56
Contact metamorphism produced by action of gabbro on granite, 36
County House mountain, 60, 61; fault, 51
Crane mountain, 6, 11, 12, 20, 46, 48, 49, 60, 61, 63, 67, 68
Crystalline limestone, 10, 15
Cushing, H. P., cited, 29, 34, 47, 59, 64

Daggett pond, 14, 18, 25, 38, 45, 50, 79
Daly, cited, 35
Davis, W. M., cited, 64
Diabase, 7, 38-44, 77; analyses, 40-42; lack of variation of, 43
Diallage, 29, 30, 31
Dikes, 77
Diorite, 30

Eakle, analyses by, 43
Economic geology, 78-85
Emmons, E., cited, 7
Exfoliation domes, 62-64

Faults, 45-58, 78
Feldspar, 12, 14, 21, 22, 30, 31, 38, 39, 83
Feldspar-biotite-garnet gneisses, 13
Feldspar-quartz, 13, 14
Folding, 59-60
Foliation, 58-59
Friends lake, 7, 54, 57, 74
Fuller pond, 13, 55, 79, 80

Gabbro-diorite, 30
Gabbros, 7, 26-37, 38, 58, 62, 76; analyses, 32-34; mineralogical composition, 29; as road metal, 84
Gage mountain, 25, 61, 65
Gage-Stockton mountain fault, 54
Garnet, 12, 13, 14, 19, 22, 28, 29, 30, 31, 33, 37, 78-82
Garnet gneiss, 13, 16, 23, 25
Geological history, summary, 76-78
Geology, 6-8
Glacial and postglacial geology, 65
Glacial lakes, 69-74
Glacial till, 69
Glen, The, 14, 19, 20, 38, 54, 58, 84
Glen brook, 6, 20
Glen glacial lake, 73-74
Glen-Riparius fault, 54
Gneisses, 12-14, 15, 16, 22; mixed, 23-26
Gore mountain, 79, 81
Granite, 18-21, 25, 36, 58, 60-61, 76; as road metal, 84; as building stone, 85
Granite gneiss, 23, 26

Digitized by Google

Granite porphyry, 21-22, 23, 25, 58, 76; as road metal, 84; as building stone, 85
Granitic hornblende syenite, 17, 18
Granitic syenite, 38
Graphite, 12, 13, 14, 25, 82-83
Graphite schists, 14, 15
Green hill, 56
Grenville limestone, 25
Grenville gneiss, 22, 23, 25, 26, 51, 55, 85
Grenville series, 6, 7, 8-16, 46, 47, 48, 76; areal distribution, 9; stratigraphy, 14-16

Hackensack mountain, 6, 11, 26, 38, 51, 61, 63
Harker, cited, 26
Heath mountain, 20, 25, 38, 40, 45, 50, 58, 61, 63, 69, 70, 84
Henderson mountain, 24, 65; faults, 56
High Street village, 44
Hill, B. F., cited, 8
Hillebrand, W. F., analyses by, 34
Holcombville, 12, 73, 79; fault, 55
Horicon, 5, 24, 53, 85
Horicon gneiss, 22
Hornblende, 12, 13, 17, 18, 19, 20, 21, 22, 28, 29, 30, 31, 33, 37, 58
Hornblende-feldspar gneiss, 13
Hornblende gabbro, 30
Hornblende-garnet-feldspar gneisses, 12
Hornblende gneiss, 15, 25
Hornblende granite, 20, 59
Hornblende norite, 29
Hornblende syenite, 30, 58
Huckleberry mountain, 6, 46, 48, 49, 61, 63, 65
Hudson river, 6, 54, 56, 73, 74, 75; preglacial, 75
Hudson River valley, 67
Hypersthene, 13, 29, 30, 31, 33, 37

Igerna, 56
Ilmenite, 28, 29, 30, 31, 33, 40, 41, 42

Johnsburg, 5, 14, 39, 59, 62, 67
Johnsburg glacial lake, 73

Kames, 69
Kelm mountain, 6, 22, 23, 24, 48, 61, 63, 84; fault, 51
Kelm pond, 51, 60
Kemp, J. F., analyses by, 43; cited, 7, 8, 18, 20, 22, 31, 34, 44, 45, 59, 64

Labradorite, 30, 40, 42
Lacroix, cited, 31
Lakes, existing, 74; glacial, 69-74
Leeds, analyses by, 43
Leucoxene, 40
Limestone, 10, 60
Little-Crane-Huckleberry mountain faults, 48-50
Little Falls dolomite, 44, 45, 77
Little mountain, 6, 9, 18, 46, 48, 49, 50, 63
Little Mountain pond, 11
Loon lake, 7, 10, 13, 14, 18, 20, 28, 53, 54, 57, 69, 72, 74, 84
Loon Lake mountain, 68; fault, 57
Luzerne river, 75

Magnetite, 12, 13, 14, 17, 19, 22, 37, 42, 44
Marble, 11, 25, 43, 85
Meade pond, 72
Merrill, G. P., cited, 11
Mica, 83
Microcline, 13, 17, 19, 20, 22, 37
Microperthite, 13, 14, 17, 18, 19, 22, 37
Mill brook, 72
Mill creek, 6, 14, 38, 56, 73, 79
Mill mountain, 6, 20, 54, 58, 61, 63
Miller, W. J., cited, 8, 34
Millington brook, 73, 74; fault, 51, 52
Monoclinic pyroxene, 17
Monzonite, 30
Moon mountain, 6, 25, 45, 48, 61, 63, 69, 70
Moon-Hackensack mountain fault, 51
Moose-No. 9 mountain faults, 50
Morley, E. W., analyses by, 32, 34, 40, 43
Mountain Spring lake, 27, 28, 36
Mountains, 6
Moxham mountain, 55
Mud pond, 67

Digitized by Google

Muscovite, 12, 38

Natural Bridge, 10, 11
Newland, David H., cited, 7, 8
Norite, 29
North Creek, 5, 11, 62, 85
North Creek fault and branch, 54
North Creek glacial lake, 73
North Hudson, 72
North River village, 44, 55
Northville, 21

Obsidian, 39
Ogilvie, cited, 65
Olivine, 29, 30, 31
Olivine norite, 29
Orthoclase, 13, 14, 17, 18, 19, 22, 28, 29, 33, 37, 38
Oven mountain, 12, 46, 55, 59, 61, 78, 81; faults, 54

Paleozoic outliers, 44-45
Paradox lake, 72
Patterson brook, 6
Pegmatite, 7, 38
Pegmatite dikes, 77
Peneplains, 64-65
Phlogopite, 12, 14
Pine mountain, 12, 56
Pine-Gage mountain mass, 61, 65
Plagioclase, 13, 17, 18, 19, 22, 28, 29, 33, 37, 40, 41, 42, 44
Porphyry, 19, 21-22, 58, 76, 84, 85
Porphyry gneiss, 23
Port Leyden quadrangle, 20
Postglacial drainage changes, 75
Potash mountain, 63
Potsdam sandstone, 44, 45, 77
Potter brook, 74
Potter mountain, 6, 18, 38, 46, 50, 61, 63, 70
Potter-Birch-Heath mountain faults, 50
Pottersville, 5, 9, 12, 18, 22, 38, 59, 62, 72, 82, 84, 85
Pottersville glacial lake, 70
Prospect mountain, 6, 13, 22, 23, 46, 53, 63, 69
Pyrite, 12, 17, 29, 30, 33, 37, 39, 40, 41, 42
Pyroxene, 11, 12, 14, 17, 18, 25, 28, 58
Pyroxene gneisses, 14, 25, 60
Pyroxene syenite, 17-18

Quartz, 11, 12, 14, 17, 18, 19, 20, 21, 22, 28, 29, 30, 37, 40, 41, 58
Quartz syenite, 16-18
Quartzite, 12, 14, 15, 16

Riverside, 18, 20, 84
Road metal, 84

Schroon lake, 7, 74; faults, 56
Schroon Lake village, 44, 72
Schroon river, 6, 70, 72, 75
Serpentine limestone, 11
Serpentine marble, 43
Sillimanite-feldspar-garnet gneisses, 14
Sillimanite gneiss, 15
Smith pond, 74
Smyth, C. H., cited, 28
Sodom, 9, 12
South Horicon, 14, 26, 69, 72
Starbuckville, 14, 59, 62, 72
Steiger, George, analyses by, 34
Stockton mountain, 6, 25, 54, 58, 63, 67
Stony Creek gorge, 70
Structural features, 45-61
Sullivan pond, 47, 52
Syenite, 16-18, 25, 29, 38, 58, 76; as road metal, 84; as building stone, 85
Syenite gneiss, 23, 26
Syenite-granite, 7, 60-61

Theresa formation, 44
Thirteenth lake, 79
Thurman, 9, 11, 14, 16, 50, 59, 60, 61, 63, 67, 83, 85
Till, 69
Titanite, 11, 17, 29, 30
Topography, 6-8, 61-65; relation to rock character, 61-62; relation to rock structures, 62
Tourmalin, 38
Trap rock, 84
Tremolite, 11, 12
Tripp mountain, 63; faults, 52
Tripp pond, 61, 69, 74; fault, 52
Trout brook, 70, 83
Tug Hill, 65

Digitized by Google

Valentine pond, 9, 13, 16, 57, 61, 62, 68, 72, 74
Verde antique, 85

Warner pond, 39, 61
Warrensburg, 5, 6, 11, 38, 62, 70
Warrensburg glacial lake, 69
Wells, 45
Wevertown, 5, 56, 68
Wolf Pond mountain, 25, 58
Woodworth, J. B., cited, 66, 72

Zircon, 17, 19, 22, 29, 30, 37
Zoisite, 17, 19, 22, 29, 30, 37

Digitized by Google

Glacial striae

Mines and quarries

Limestone outcrops

AA, BB, CC, DD and EE, are the lines of structure sections shown in figures 1, 5, 6, 7 and 8 respectively.

by W. J. Miller,
0-1911

Digitized by Google

Digitized by Google

11,983

University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the act of August 24, 1912

Published fortnightly

No. 571 ALBANY, N. Y. JULY 15, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 171

THE GEOLOGY OF THE SYRACUSE QUADRANGLE

BY

THOMAS CRAMER HOPKINS

	PAGE
Introduction	5
Geologic column of the Syracuse area	6
Stratigraphy	7
Economic geology	26
Structural geology	38
Physiographic features	40
Peridotite dikes	45
Notes on the Fossils of the Paleozoic Formations within the Syracuse Quadrangle. BURNETT SMITH	57
A Review of the Mammalian Remains from the Superficial Deposits in the Vicinity of Onondaga Lake, New York. BURNETT SMITH	64
Explanations of plates	73
Index	77

ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

1914

M44r-N13-1500

Digitized by Google

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of the University

With years when terms expire

1917 St Clair McKelway M.A. LL.D. D.C.L. L.H.D.
Chancellor Brooklyn
1926 Pliny T. Sexton LL.B. LL.D. *Vice Chancellor* Palmyra
1915 Albert Vander Veer M.D. M.A. Ph.D. LL.D. Albany
1922 Chester S. Lord M.A. LL.D. - - - - - New York
1918 William Nottingham M.A. Ph.D. LL.D. - - Syracuse
1921 Francis M. Carpenter - - - - - - - - Mount Kisco
1923 Abram I. Elkus LL.B. D.C.L. - - - - - New York
1924 Adelbert Moot - - - - - - - - - - Buffalo
1925 Charles B. Alexander M.A. LL.B. LL.D. Litt.D. Tuxedo
1919 John Moore - - - - - - - - - - - - Elmira
1920 Andrew J. Shipman M.A. LL.B. LL.D. - - New York
1916 Walter Guest Kellogg B.A. - - - - - Ogdensburg

President of the University and Commissioner of Education

John H. Finley M.A. LL.D.

Assistant Commissioners

Augustus S. Downing M.A. L.H.D. LL.D. *For Higher Education*
Charles F. Wheelock B.S. LL.D. *For Secondary Education*
Thomas E. Finegan M.A. Pd.D. LL.D. *For Elementary Education*

Director of State Library

James I. Wyer, Jr, M.L.S.

Director of Science and State Museum

John M. Clarke Ph.D. D.Sc. LL.D.

Chiefs of Divisions

Administration, George M. Wiley M.A.
Attendance, James D. Sullivan
Educational Extension, William R. Watson B.S.
Examinations, Harlan H. Horner B.A.
History, James A. Holden B.A.
Inspections, Frank H. Wood M.A.
Law, Frank B. Gilbert B.A.
Library School, Frank K. Walter M.A. M.L.S.
Public Records, Thomas C. Quinn
School Libraries, Sherman Williams Pd.D.
Statistics, Hiram C. Case
Visual Instruction, Alfred W. Abrams Ph.B.
Vocational Schools, Arthur D. Dean D.Sc.

Digitized by Google

AUG 6 1914

The University of the State of New York
Department of Science, October 31, 1913

Hon. Pliny T. Sexton LL.D.
Vice Chancellor and Acting Commissioner of Education

MY DEAR SIR:

I beg to communicate herewith a manuscript, with maps, entitled *The Geology of the Syracuse Quadrangle,* and to recommend this for publication as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

Approved for publication this
5th day of November, 1913
PLINY T. SEXTON,
Vice Chancellor of the University

Digitized by Google

Digitized by Google

University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the act of August 24, 1912

Published fortnightly

No. 571 ALBANY, N. Y. JULY 15, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 171

THE GEOLOGY OF THE SYRACUSE QUADRANGLE

BY

THOMAS CRAMER HOPKINS

INTRODUCTION

The Syracuse topographic quadrangle, which is here specially under consideration, includes an area one-fourth of a degree square, in latitude 43°–43° 15′ N. and longitude 76°–76° 15′ W. Situated near the geographic center of the State of New York, including part of two of the great physiographic regions of the State, and the outcropping edges of many of the stratigraphic units of the paleozoic rock series, it has many features in common with, and hence may be taken as typical of, a rather broad belt extending east and west through the middle of the State.

The city of Syracuse is on the line of the Erie canal; lies at the intersection of the east-west (New York Central and West Shore) and the north-south (Delaware, Lackawanna and Western) railways, and has besides several branch lines radiating from the city and several suburban electric lines. Central location and excellent transportation facilities make it an important commercial center.

This quadrangle is located on the border line between the lake plains on the north and the Alleghany plateau on the south, two of the distinctive physiographic regions of the State. It has a varied physiography, which is somewhat intensified by glacial action. Passing across the quadrangle are the outcropping edges of the Siluric rocks with the lower and middle Devonic rocks on the hills near the

Digitized by Google

city. Several of the stratigraphic type localities are near the city, namely, Camillus, Manlius, Onondaga, Marcellus, Cardiff, Skaneateles, Tully and Salina.

The soils in the vicinity of the city consist of mixed glacial clays, sand and gravel on the upland, and muck, marl, alluvium, lacustrine deposits, sand, gravel and boulder clay on the lowlands.

The map shows the topography and the outcrop of the different units in the sedimentary series. No attempt has been made to indicate the different soils or the special glacial features.[1]

GEOLOGIC COLUMN OF THE SYRACUSE AREA

Devonic	Erian	14 Cardiff shale 13 Marcellus shale including Cherry Valley or Agoniatites limestone
	Ulsterian	12 Onondaga limestone
	Oriskanian	11 Oriskany sandstone
	Helderbergian	10 Coeymans ? limestone
Ontaric or Siluric	Cayugan	9 Manlius limestone 8 Rondout waterlime 7 Cobleskill dolomite Salina beds 6 Bertie waterlime 5 Camillus shale including Fiddler's Green limestone and gypsum 4 Vernon shale 3 Pittsford shale
	Niagaran	2 Lockport limestone 1 Clinton beds including Rochester shale

[1] The soils are mapped and described in the Soil Survey of the Syracuse Area, New York, by F. E. Bonsteel, William T. Carter jr, and O. L. Ayres in the Field Operations of the Bureau of Soils 1903. Washington 1904.

Certain glacial features, especially the east-west channels and the drumlins, have been mapped and described by H. L. Fairchild in State Museum Bulletins 111, 127 and 160.

Digitized by Google

STRATIGRAPHY

As indicated on the foregoing table, there are 14 units, with a few subdivisions, of the paleozoic rock series of New York represented on the Syracuse quadrangle. Of these, 12 are represented in color on the map. The lowest group on the area is that of the Clinton shale in the midst of the Siluric, and the upper one is the Cardiff shale of the Mesodevonic.

NIAGARAN GROUP

CLINTON-ROCHESTER SHALES

These oldest rocks of the Syracuse region consist of shales which outcrop in the village of Brewerton at the west end of Oneida lake, exposed in the dredgings of the barge canal at Brewerton and in a cutting on the same canal near Three River point. These exposures occur in a rather wide area between the dark (Lockport) dolomite on the south and the red (Medina) sandstone on the north, the remainder of the intervening area being covered with a thick mantle of glacial drift. The entire area is underlain by the Clinton and the Rochester shales but present data are not sufficient to distinguish the two areas separately. The shales exposed in the village of Brewerton are an olive green which oxidizes to a reddish and yellowish brown. The shale is friable and not very resistant to the action of the weather. That dredged from the canal has a bluish color and crumbles very rapidly on exposure to the weather. It is calcareous and contains many fossils.[1]

A test hole drilled at Brewerton about 75 yards west of the highway bridge near the Onondaga-Oswego county line gave the following section:[2]

14 feet		Clay
42 feet	4 inches	Olive gray shale with a few thin bands of limestone. At 19 feet from surface there is a 4 inch band with black pebbles
	2 inches	Fossil ore inclosed in shale
23 feet		Shale with limestone bands 3 to 4 inches thick at regular intervals. Cavities lined with crystals; ore in threadlike veinlets in the limestone

[1] See page 57 for a discussion by Dr Burnett Smith of the paleontology of this group, and all the other groups of the area.

[2] D. H. Newland and C. A. Hartnagel. State Mus. Bul. 123, p. 37.

Digitized by Google

58 feet 10 inches.		Shale with thin bands of limestone. Traces of ore at 133 feet
	16 inches	Oolitic iron ore
5 feet	4 inches	Sandstone and shale
145 feet		Total depth

Analysis of the oolitic iron ore from the drill hole at Brewerton.[1]

Fe_2O_3	48.71
SiO_2	9.69
TiO_2	.244
Al_2O_3	3.21
MnO	tr.
CaO	13.8
MgO	4.23
SO_3	.141
P_2O_5	2.38
CO_2	15.45
H_2O	2.33
	100.185
Iron	34.1
Phosphorus	1.038

A deep well-boring at Chittenango in 1890 indicated a thickness of 323 feet of Clinton shales between 567 and 890 feet below the surface, according to the interpretation of Prosser.[2]

The State well drilled at the south end of Onondaga lake in the city of Syracuse in 1884 gave, according to the interpretation of Prosser and Englehardt,[3] a thickness of 98 feet of Clinton and 332 feet of Niagara, and the Gale well on the east side of the lake, according to the same authorities, gave 149 feet of Clinton and 320 feet of Niagara.[4]

[1] Ibid, p. 38.

[2] C. S. Prosser. Bulletin of the Geological Society of America, v. 4, p. 98, 1893.

[3] Ibid, p. 102.

[4] For further particulars concerning the distribution of the Clinton in central New York, see Bulletin 123 of the New York State Museum by Newland and Hartnagel; and Thickness of Devonian and Silurian Rocks in Central New York by C. S. Prosser, in Bul. Geol. Soc. of America, v. 4, 1893, p. 91.

Digitized by Google

LOCKPORT LIMESTONE

Overlying the Rochester-Clinton shale is the Lockport limestone, known in the older reports as the Niagara limestone. It consists of a very dark colored, in places black, dolomitic limestone and associated shales. It contains numerous small geodic cavities lined with calcite and dolomite crystals.

This limestone forms a rather broad belt across the Syracuse quadrangle. The rock is more resisting to the action of the weather than the shales above and below and hence is characterized by a slight topographic relief. This relief is even less than one might expect from the difference in the rocks, which is probably due in part to the leveling action of the ice during the glacial period and the inequalities of the glacial deposits; possibly also the area was nearly base-leveled before the advent of the glacier.

The outcrops of the Lockport limestone, while not numerous owing to the heavy glacial covering, are more extensive than that of the underlying shales. The best exposure on the Syracuse area is at the quarry on the South Bay electric road about one mile south of Oneida lake. The greater part of the rock here is a nearly black dolomite. The upper layer is evenly bedded, varies from 1 to 2 feet in thickness, has a finely crystallized, even texture and is a fairly good building stone. The layers immediately underlying the top bed are more thinly bedded and interlaminated with black carbonaceous shale. At a depth of 4 to 6 feet the limestone occurs in rough irregular masses with no regular lamination or grain. In the bottom portion of the quarry the shale prevails over the limestone.

On the White farm immediately south of the quarry the rock has been removed over an area several acres in extent. It has been nearly all used for foundations, culverts and bridge piers. Its extended local use is due rather to the fact that it is the only rock obtainable for building purposes between the plateau south of Syracuse and the Medina sandstone area some miles to the north.

A similar rock at or near the same horizon as that at the quarry mentioned above has been quarried to a limited extent for local use at the village of Cicero, two and a half miles southwest of the barge canal at Oak Orchard on the Oneida river, and in the bank of the Seneca river a half mile south of Three River point. There is another quarry in this rock two and a half miles northwest of Baldwinsville and another on the western border of the village of Lysander. Both of these localities are on the Baldwinsville

Digitized by Google

quadrangle. There is a small abandoned quarry near Clay station and a small outcrop at Bridgeport on the Chittenango quadrangle.

The outcrop of the comparatively hard Lockport limestone under the less resistant Vernon shale with both strata dipping south caused an obstruction to the north flowing streams. In the base leveling of the region the limestone would remain as a ridge after the overlying softer shales were worn down to a plain which on subsequent uplift would cause a damming of the streams and overflow over the area of the softer rocks. During the glacial period the erosion by the ice and the glacial waters further lowered the shale areas south of the limestone outcrop, causing a depression in which the water stood after the melting of the glacier, thus producing the flooded area of Cicero swamp and the westward extension of the flooded area in the Montezuma swamp district.

CAYUGAN GROUP

Salina Beds

PITTSFORD SHALE

The Pittsford shale has not as yet been recognized in the Syracuse area but this may be due to the fact that this horizon is concealed by the heavy mantle rock rather than to the absence of the shale. The first rock that has been observed outcropping above the Lockport limestone is the Vernon shale.

VERNON RED SHALE

Overlying the Lockport limestone is a great thickness of argillaceous shales, red and variegated at the base, gray to drab colored toward the top. Mingled with the upper gray shales are beds of calcareous and magnesian limestones, gypsum and rock salt, merging at the top into argillaceous dolomites or waterlime beds. In many of the older reports which followed Dana's classification, this whole series of beds is called the Onondaga Salt group and the argillaceous division at the bottom is called the Salina group, in distinction from the overlying waterlime beds. The Onondaga Salt group was divided into four divisions, the lower being the red shale, now called the Vernon shale, from the village of Vernon, in Oneida county.

It is difficult to determine accurately the exact thickness of the Vernon shales in this area. According to Prosser and Englehardt's interpretation of the Gale's well record made in 1884, there are 392 feet in that well boring; the well started in the shale, but how far

Digitized by Google

from the top is not known, probably 50 to 100 feet. A rough determination from the outcrop of the shales and the dip of the strata would indicate a thickness of nearly 700 feet, but the dip of the shales may differ from that of the rocks in the plateau to the south; nor is there at present, without some well records, anything to show the uniformity or lack of it in the strata under the heavy overburden of rock.

The Vernon shale is a soft, argillaceous, hematite-red shale, but in a number of places the red is mottled with green. In places the green occurs in small masses the size of one's hand; elsewhere it forms huge masses of the deposit and sometimes there is an intermingling of the two colors.

The bright red color is due to diffused anhydrous ferric oxid. In the outcrop on the bluff on the north side of Onondaga lake some of the hematite occurs in brilliant crystals, but the greater part of it is intimately diffused through the mass of the shale. The green color in the shale is due to iron in the ferrous or lower oxid state. Part, if not all, of the color comes from the glauconite. The presence of some organic matter in the green spots has prevented the oxidation of the iron to the ferric state or has reduced any ferric iron that may have been present.[1]

Probably the largest outcrop of the Vernon shales on the Syracuse quadrangle is in the bluffs on the north side of Onondaga lake along the Oswego canal. Near the bottom of this outcrop there are several layers of rather coarse sandstone, the only sand that has been observed in the shale in this area. About 40 feet of the shale are exposed on the bank of the canal, and at the schoolhouse an eighth of a mile north of the canal is another exposure of about 20 feet, more than 100 feet above the bottom of the lower opening.

The shale is to be seen in a number of places north of the Erie canal, the best exposures being those at the north end of Wolf street, on the Syracuse-Oak Orchard road south of Cicero swamp, and at the New York Central railway yards at Dewitt. It underlies and forms the base of the hill in the north part of the city of Syracuse, and surrounds and probably underlies part or all of Onondaga lake. It may underlie the depression in which the Erie canal passes through the city, but there are no excavations or drill records by which to locate its boundaries here. There is one outcrop on the south side of the Erie canal, at Belle Isle on the west margin of the quadrangle, where the shale has been quarried and used for the

[1] W. J. Miller. N. Y. State Museum Bul. 140, p. 153.

Digitized by Google

manufacture of red brick. It has been used in large quantities for the same purpose at the village of Warner, a few miles west of Syracuse, and also near Kirkville some miles east of Syracuse.

The glacier that passed over this region removed large quantities from the outcrop of these red shales, distributing the material over the area south of the outcrop, thus leaving a rather broad belt across the area in which the soil covering is prevailingly red from these shales.

CAMILLUS BEDS

The Camillus includes a large part of the upper division of the Salina beds and embraces all the series of shales, gypsum, salt and limestones between the red Vernon shales below and the Bertie dolomite above. In this area it consists, from the top downward of:

1 Gypsum and gypseous shales
2 Thin bedded limestone (Fiddler's Green)
3 Gray to greenish colored shales inclosing deposits of salt and gypsum, with vermicular limestone and other calcareous layers.

The total thickness of the Camillus beds in the Syracuse area is about 600 feet and the outcrop forms a broad band across the quadrangle next in size to that of the Vernon shale. The upper gypsum bed, the underlying thin bedded (Fiddler's Green) limestone, and the vermicular limestone are well-defined lithologic units and mark definite horizons in the great bed of gray shales.

The *upper gypsum bed* varies from 25 feet to 63 feet in thickness in different parts of the area. It is an impure mass of gypsum with a variable percentage of intermingled shale and mud layers, but is the bed from which almost all the great quantities of gypsum quarried in the county have been obtained. The large and old quarries, some of which were operated more than a century ago, at Lyndon, between Lyndon and Jamesville, and those in the vicinity of Fayetteville and Manlius are all at this horizon. It contains a thin layer of salt at Lyndon.

Fiddler's Green limestone, immediately underlying the upper gypsum bed, varies from 20 to 40 feet in thickness and is a persistent bed across the quadrangle and beyond. It is a thin-bedded limestone dolomitic in character and, being more resistant than the overlying gypsum and the underlying shales, has a strong topographic relief, so that the surface exposures are much greater than any other portion of the entire Camillus group. The weathered surface of some of the layers is characterized by many sharp narrow grooves as though made by a knife, frequently forming two series cutting

Digitized by Google

Plate 1

Gypseous shale (Camillus) overlain by Bertie dolomite. In Miller's gypsum quarry near Lyndon, N. Y. Gypsum exposure 40′ and 20′ extends below floor of quarry

Digitized by Google

Digitized by Google

the surface into rhomboidal figures. Some of the layers are characterized by great numbers of the small ostracod Leperditia scalaris.

The limestone was quarried many years ago in the hill a half mile southeast of the university campus, and several other places in the region, for use in foundations, but its use has been very limited because as a building material it is inferior to the limestones in the overlying strata. It has been used locally in large quantities for constructing stone fences where the principal object was probably to rid the surface of the stone to make the land tillable.

Good exposures of this rock may be seen in the area north of the Split Rock quarries, in Chrysler's glen, in the Elmwood valley, in the rock cut on the Delaware, Lackawanna and Western Railroad south of Syracuse, at the east end of the railway channel, over large areas between the railway channel and the city, between Lyndon and the gypsum quarries and nearly continuous for several miles along the south side of the channel extending east from Real's station on the Jamesville trolley line, and best of all in the gorge below the falls at Fiddler's Green, which suggests the local name used for this bed. At Fiddler's Green both in the gorge and along the trolley line below the gorge it contains several well-marked thrust faults. Several smaller faults also occur in the rock cut in the railway channel. Stylolite markings occur at several exposures in this limestone, but are not limited to this horizon as they show to even better advantage in some of the dolomites higher in the series.

The remainder of the Camillus group underlying the Fiddler's Green limestone, nearly 500 feet in thickness, consists of argillaceous shales with several beds of limestone, rock salt and gypsum scattered through them. The limestones and the salt beds form distinct strata in the series but the gypsum occurs in threads, veins, and masses, diffused through the shale and nowhere forms persistent beds of any great thickness. Some of the gypsum is of the fibrous or satin spar variety and some of it is the transparent and translucent selenite. Considerable quantities of the selenite variety of gypsum were exposed in excavations on the university campus and in the quarries on the bank of the canal north of Fayetteville.

The shales are exposed in many of the excavations in building construction in the city and they outcrop on the surface in many places through the glacial drift covering. Among the many exposures where the shale may be seen and studied are the stream banks at Chrysler station on the Auburn suburban line, the cuttings

Digitized by Google

along the same line, the bluff back of the Cold Spring brewery, in Elmwood park, the Delaware, Lackawanna and Western Railroad cut at Croton street, excavations on the university campus, along University and Crouse avenues and East Genesee street, several places along the Erie canal east of the city, and along the Suburban line to Manlius.

The *vermicular limestone* was described by Vanuxem in 1842[1] as follows: "It is a porous or cellular rock strongly resembling porous or cellular lava. It derived its name from the several holes, which were still lined with a kind of tubular calcareous shell or crust, in some measure resembling the tubular covering of the Serpula . . . but evidently the result of the simultaneous forming of the rock and of a soluble mineral whose removal caused the cells in question."

There are layers of a similar porous rock in the dolomites overlying the Camillus group. In the layers of the Cobleskill and Rondout waterlimes in the cutting for the trolley line at Fiddler's Green, near Jamesville, the spaces in the fresh rock were filled with celestite crystals. These were first described by Dr E. H. Kraus.[2] This led to the conclusion that the cavities in the vermicular limestone at several horizons in the Camillus group were also due to this mineral which had been dissolved on the weathered exposures. So far as known to the writer, no celestite crystals have been found in the vermicular limestone of the Camillus group, but the similarity of the rock to that at Fiddler's Green justifies the conclusion that the origin of the cavities is the same.

There is a fairly persistent bed of this vermicular rock in the city of Syracuse. It outcrops on the Delaware, Lackawanna and Western Railroad at Croton street, on Van Buren street, Henry street, on Crouse and University avenues at the same horizon, again on East Genesee street, and at several places east of the city, the best and largest exposure of all being along the Chenango branch of the West Shore Railroad a mile north of Fayetteville. There is a bed of limestone at or near the same horizon on the hill south of the Erie canal about a mile east of the city of Syracuse which is probably part of the same bed but here it has no vermicular cavities. There are calcareous and dolomitic layers in the Camillus shales at other horizons, notably near the bottom of the series in the hill in the north part of Syracuse. These limestones, so far as observed,

[1] Geology of New York, pt 3, by Lardner Vanuxem, pp. 101, 273, 279.
[2] Am. Jour. of Science, v. 18, July 1905.

Digitized by Google

Plate 2

Fiddler's Green limestone in the gorge at Fiddler's Green

Fiddler's Green limestone (Camillus) a mile west of Elmwood park, Syracuse, N. Y., overlain and underlain by soft shale

Digitized by Google

Digitized by Google

are thin bedded and sometimes very hard, but tend to crumble on exposure to the weather, so that they do not appear at the surface in many places except where exposed by excavations.

BERTIE WATERLIME

The upper division of the Salina series immediately overlying the gypsum of the Camillus group, consists of a gray to buff-colored waterlime or dolomite. In this vicinity it is from 6 to 10 feet thick, made up of evenly bedded layers varying from a fraction of an inch to a few inches thick.

The stratum has been named from the town of Bertie, 6 miles west of Buffalo, in the province of Ontario. In Ontario and around Buffalo in western New York the Bertie waterlime is characterized by a rich eurypterid fauna, but no eurypterids, or in fact fossils of any kind, have been found in it in the Syracuse area. Since there is no unconformity of erosion at either the bottom or the top of this limestone and since it resembles lithologically the other waterlimes of the area, it has been separated from the other strata only by tracing it from the west where it is distinguished from the others by its fossil contents.

The upper part of the waterlime has been quarried extensively for the production of cement at Buffalo, Williamsville and Akron in western New York. At Buffalo it is 53 feet thick. Very little use has been made of it in the Syracuse area because the Manlius waterlime in the overlying rocks furnishes a superior quality of waterlime to the Bertie in this locality. A small quantity of it was used for cement in the Miller quarry a mile south of Lyndon in order to lessen the expense of quarrying the gypsum as the limestone had to be removed in order to get the underlying gypsum.

COBLESKILL DOLOMITE

The Cobleskill dolomite immediately overlies the Bertie waterlime in this locality without any sharp line of separation. In most places the Cobleskill contains numerous cavities about the size of a walnut or smaller, caused by the leaching out of a small coral, Cyathophyllum hydraulicum. In some places there are many irregular masses or lumps of chert scattered through the Cobleskill, and in general the bedding planes are more irregular than in the Bertie. It also resists the action of the weather better so that it stands out more in relief. In some localities, especially at Fiddler's Green, near Jamesville, the stylolite or suturelike markings

Digitized by Google

are very pronounced. They can not be said to characterize the Cobleskill dolomite since they occur, though not so abundantly, in the other dolomites, particularly in the Fiddler's Green limestone. The stylolite markings are described by Vanuxem in his report in 1840; he calls them Epsomites and says they are due to the crystallization of epsom salts or magnesium sulphate in the limestone muds.[1] Several other explanations have been offered to account for these peculiar markings but none of them are altogether satisfactory.[2]

The best exposures of the Cobleskill dolomite and Bertie waterlime on the Syracuse quadrangle are at the Miller and Heard gypsum quarries a mile south of Lyndon and a half mile north of White lake; and in the ravine south of Chrysler's station on the Auburn suburban line. Other good exposures of the same rocks are on the hill above Manlius Center, on the electric line north of Jamesville, and at several localities near the western margin of the map.

At Cobleskill, the type locality for this limestone, it is about 6 feet thick, the same as at Syracuse. It thins out to some extent in Ontario county to the west and then increases in thickness to 14 feet in Erie county, where it is known as the "bullhead" or "pumpkin" limestone. In the older reports it is the "Coralline limestone" of Hall, with which it was correlated by Hartnagel in 1902. Previous to that time it was considered part of the Manlius limestone in the Syracuse area.

RONDOUT WATERLIME

The upper portion of the dolomite beds has been correlated by Hartnagel with the Rondout waterlimes. In this locality it comprises a greater thickness than the Bertie and Cobleskill beds combined. By greater lithologic changes it indicates a greater change in geographic conditions than do the others. So far as this area is concerned, it marks a long, fluctuating, transitional stage from the gray argillaceous dolomites of the underlying groups to the more compact, less magnesian, blue limestones of the overlying Manlius formation.

The Rondout of this region consists of gray dolomites interstratified with shaly layers grading, in places, into argillaceous shales. The upper part of the bed contains many finely straticulate layers with narrow bands of more calcareous limestone. Some of the layers near the base are richly impregnated with celestite crystals.

[1] Nat. Hist. N. Y., Geol. Surv. Third District, 1842.

[2] Am. Jour. Sci., 4:142, 1897.

Digitized by Google

and surfaces where these crystals have been leached out give the rock a vermicular texture similar to that of the vermicular limestone in the Camillus group.

Good exposures of the entire thickness of the Rondout are not frequent in the Syracuse quadrangle, because it is in general less durable than the overlying Manlius and Onondaga limestones which form cliffs and their fragments form talus slopes covering the Rondout. The best exposure on the quadrangle is in the ravine south of Chrysler's station on the Auburn electric line, where nearly every layer at this horizon is exposed. There is a good exposure along the electric line between Dunlop station and the penitentiary near Jamesville. This is on the northern margin of the Tully quadrangle. Other exposures near Syracuse are at Kimber springs on the west side of Onondaga valley (Tully quadrangle) and several places along the escarpment between Jamesville and Manlius.

The Rondout limestone is not used commercially at Syracuse, except locally for road ballast or rough building stone, because it is inferior to the overlying limestones as a waterlime, quicklime, or building stone.

MANLIUS LIMESTONE

The name Manlius was first used by Vanuxem[1] in 1842 as the "Waterlime group of Manlius," apparently including under this term the waterlimes of the underlying Bertie and Camillus groups. The name subsequently gave way to Tentaculite limestone until it was revived by Clarke and Schuchert[2] in 1899. In the type locality at Manlius, Hartnagel[3] gives a total thickness for the Manlius of 77 feet from the upper waterlime bed at the top to the Rondout, into which the Manlius grades without any sharp line of separation. This conception differs somewhat from that of Schuchert[4] and from that of Harris.[5] The difference seems to be in the delimitations at the top and base. There is still some question as to whether the Manlius properly terminates with the upper waterlime or should include the overlying Stromatopora layer and some of the accompanying blue limestone and, if so, how much. As the waterlimes are persistent and quite uniform in character in the Syracuse region,

[1] Geol. N. Y., Third District, 1842, p. 110–16.

[2] Science, 10:874–78, 1899.

[3] N. Y. State Mus. Bul. 69, Rep't of State Pal. 1902, p. 1165.

[4] On the Manlius Formation of N. Y. Schuchert. Am. Geol., March 1903, p. 160.

[5] American Paleontology. Bul. 19. Ithaca, N. Y. 1904.

Digitized by Google

Hartnagel's section terminating the Manlius with the upper waterlime is very satisfactory for this area from a lithologic standpoint. Since the Manlius group terminates the Siluric sediments of this region, it has exceptional interest to the geologist. The thickness and general characteristics of the beds in the group are remarkably uniform across the Syracuse quadrangle, more so than that of the immediately overlying limestones.

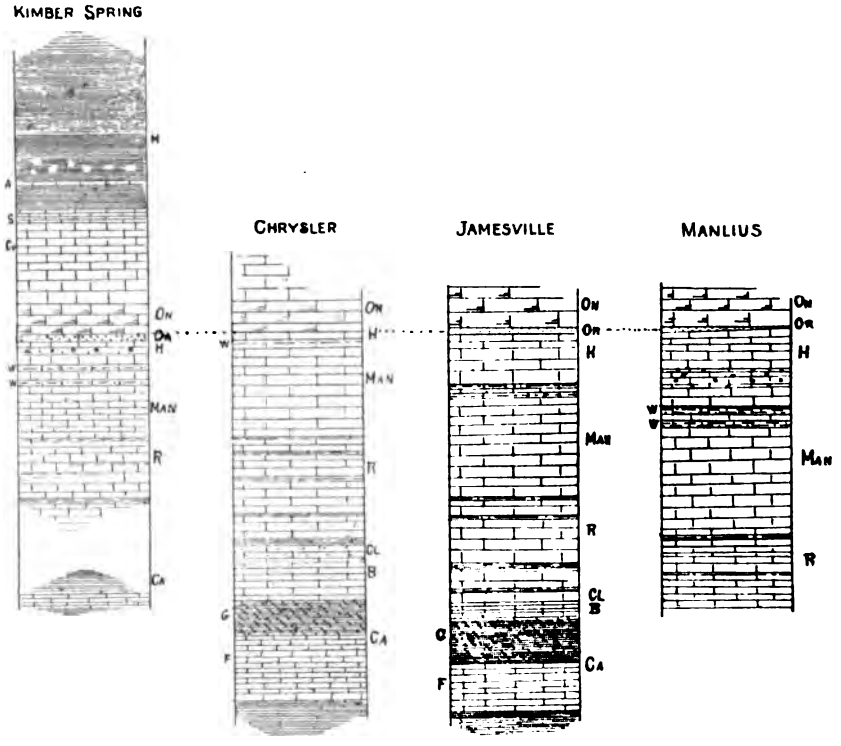


FIG. 1. Vertical sections of Manlius and associated groups

At the top of the group is a bed of waterlime generally about 4 feet thick, varying slightly in different localities, underlain by 4 to 5 feet of blue limestone known in the local quarries as the "diamond blue." It is a compact, calcareous limestone, comparatively pure, with many joint and fracture planes so that it comes from the quarry in small fragments. The blue limestone is underlain by a second bed of waterlime similar in character and thickness to the upper one. Or we might think of it as one bed of waterlime separated into two by a bed of blue limestone 4 to 5 feet thick through the middle of it.

Digitized by Google

The waterlime is an argillaceous dolomite in which the clay is intimately mixed through the carbonates in about the right proportion to make a good quality of hydraulic cement when it is burnt and ground. It was first used in large quantities about the year 1820 in the construction of the Erie canal and has been quarried and burnt for cement in variable quantities from that time to the present. The extent of the industry is indicated by the great number of quarries which are almost continuous along the outcrop across the area. The largest quarries are in the vicinity of Manlius, Fayetteville, Jamesville and along the escarpment between Onondaga valley and the Split Rock quarries. The industry has declined in recent years owing to the rapid increase in the manufacture of the Portland cement.

The portion of the Manlius limestone underlying the waterlime layers consists mostly of blue, in places nearly black, limestone in layers of varying thickness. Mingled with these compact calcareous layers are some drab colored finely straticulate layers of dolomite. In some layers the straticulation is so fine as to be scarcely perceptible until intensified by weathering.

The Manlius limestone is well exposed on the Syracuse quadrangle, forming an almost continuous outcrop across the quadrangle from High Bridge on the east to the Split Rock quarries on the west. It forms an important part, generally the middle portions, of the limestone escarpment that marks the northern limits of the Alleghany plateau.

The waterlime is barren of fossils in this locality. Some of the blue layers below the waterlime are very fossiliferous, the small brachiopod Spirifer vanuxemi being especially abundant near the base of the series. In the midst of the series Stromatopora is abundant, in places one layer, and in some places two layers, being composed entirely of this fossil. The Stromatopora of these lower layers strongly resembles that of the beds overlying the waterlime, but Hartnagel has found mingled with the Stromatopora in the upper bed a number of fossils of Helderbergian or Devonic age. Thus both the fossils and stratigraphy indicate that in this locality there was no very great geographic change separating the Siluric and Devonic periods.

DEVONIC

HELDERBERGIAN LIMESTONE

Overlying the Manlius limestone and occupying the interval between it and the Oriskany sandstone is a deposit of blue limestone over the greater part of this area that is correlated with the Helder-

Digitized by Google

bergian limestones farther east and is probably the equivalent of the Coeymans division of that group. There is a little uncertainty concerning the parting between this limestone and the underlying Manlius in this area.

If the upper limit of the Manlius is the upper waterlime layer of that group, as stated by Hartnagel,[1] then the problem is solved and the Helderbergian limestones extend west almost to the western border of the quadrangle; but if the upper Stromatopora layer and some of the associated blue limestone is Manlius, rather than Helderbergian as implied by Harris,[2] then Harris's further statement that the western limit of the Helderbergian is in the vicinity of Manlius is true and this group is scarcely represented on the Syracuse quadrangle. The limestones at this horizon are not markedly different from the blue limestones below the waterlime and the separation must be based on a refined study of the paleontology of the two. In the construction of the map the stratigraphy is based on the Hartnagel section and the Helderbergian extended westward until the upper waterlime and the Oriskany sandstone come together near the Split Rock quarries in the western part of the area.

Some 2 miles southwest of Manlius, in the southeastern part of the Syracuse quadrangle, there is a thickness of 50 feet of blue limestone at the Helderbergian horizon between the Oriskany sandstone and the upper Manlius waterlime. In this section the crystalline crinoidal layer of the Manlius section does not appear at all and the Stromatopora beds have a greater thickness; in fact, almost the entire thickness of 50 feet shows Stromatopora in abundance. At Jamesville, a few miles farther west, the thickness is 40 feet and at Britton's quarry, 3 miles farther west, it is 12 feet. At the Split Rock quarries on the west side of the Syracuse quadrangle it is not present at all, as the Onondaga limestone rests directly upon the Manlius waterlime.

ORISKANY SANDSTONE

The Oriskany sandstone occupies the interval between the Helderberg-Manlius limestones below and the crystalline Onondaga limestone above, and, in connection with the Onondaga limestone, forms the best key rock in working out the stratigraphy of the area. It is a coarse-grained sandstone lying in the midst of a great thickness of limestones and its position in the column need never be mistaken.

---

[1] Loc. cit.

[2] American Paleontology. Bul. 19. Ithaca, N. Y. 1904.

Digitized by Google

Plate 3

In Britton's limestone quarry 3 miles south of Syracuse. The part above the man's head is the Stromatopora limestone (Helderbergian (?)). The lower layers are the Manlius waterlime, the middle layer a compact blue limestone.

Digitized by Google

Digitized by Google

Weathered surface of the Stromatopora (Helderbergian) limestone at Manlius

Digitized by Google

Digitized by Google

The prevailing color of the Oriskany is a light gray, generally with a yellowish stain from the hydrous iron oxid. In two places in the Syracuse region it has a reddish tint from the small admixture of red hematite. In a few places it contains some pyrite crystals which on the weathered surface have oxidized to the yellowish brown oxid.

In nearly every exposure where there is any appreciable thickness of the Oriskany, it contains black nodules of calcium phosphate, nodules varying from a fraction of an inch to several inches in diameter. These phosphate nodules characterize the Oriskany in many other localities and in some places through the Alleghany ranges in Pennsylvania the nodules are quarried for use as fertilizer.[1]

In many of the exposures the rock is fossiliferous, characterized by the number of individuals rather than by number of species. The fossils are largely brachiopods, Spirifer arenosus, Rensselaeria ovoides and Orthis hipparionyx, in which the calcium carbonate of the shells has been leached out by the ground waters, leaving the large casts which makes the rock very porous. Thus where the rock is below the water table and has any appreciable thickness, it makes an excellent water reservoir.

The Oriskany sandstone varies in thickness from a small fraction of an inch to about 12 feet in the Syracuse region. It increases in thickness to the east and south, reaching a thickness of about 700 feet in central Pennsylvania. The thickest exposure in this vicinity is on the hill above Rockwell springs, on the east side of the Onondaga valley, a mile northeast of Onondaga Castle, where it is 12 feet thick, consisting in part of thin bedded reddish sandstone. On the west side of the valley above Kimber spring it is 4 feet thick. Westward from the Onondaga valley it thins out rapidly, disappearing on the west margin of the sheet, to reappear again farther west. At the Split Rock quarries it is a mere fraction of an inch in thickness, and a mile east of the quarries it does not occur at all. In Russell's quarry at East Onondaga, it is about 2 feet thick; at Britton's quarry a half mile northeast, it is nearly 3 feet thick. At Green lake, 3 miles farther east, it is 2 inches thick. On the hill east of Jamesville it is nearly 4 feet thick. Farther east in the vicinity of Manlius it is in places a few inches thick and in places absent. Clarke[2] has explained these variations in thickness as more or less

[1] M. C. Ihlseng. Bul. 34, Pa. State College Agr. Exp. Sta., Jan. 1896.
[2] Lenticular Deposits of the Oriskany Sandstone: Science 1900.

Digitized by Google

discontinuous deposits laid down on a broken coast line. The continuation of these sands westward into Erie county is striking evidence of the increasing transgression of the early Devonic deposits over the Siluric lands.

In a number of places there is a mingling of the Oriskany sand and phosphatic nodules through the bottom part of the overlying Onondaga limestone, and in some places there are fragments of the underlying Helderbergian limestones embedded in the Oriskany or with the Oriskany sand embedded in the Onondaga limestone.

The Oriskany sandstone has no commercial value in the Syracuse area, since the bed is too thin and the rock too friable for building stone and it contains too much iron for glass sand. In the Juniata valley in central Pennsylvania it is used in large quantities for glass sand. There it is several hundred feet thick and almost free from iron. In some localities in Pennsylvania it is used in limited quantities for the phosphate content for fertilizer.

ONONDAGA LIMESTONE

The term Onondaga limestone includes that great mass of limestone about 100 feet thick between the Oriskany sandstone below and the Marcellus black shale above. It now embraces all the terms formerly designated by the names Onondaga, Corniferous and Seneca. The name was improperly applied by Dana and by some of the older writers to the salt and waterlime groups of the Salina period.

The lower portion of the limestone mass is known among the local quarrymen as the "gray limestone." It has a pronounced crystalline texture and, if it were white or bright colored, would pass in the market as marble. It has a thickness varying in this vicinity from 10 to 30 feet, and occurs in fairly heavy beds from 1 to 4 feet or more in thickness. It is quite fossiliferous throughout the area, containing many well-preserved corals, crinoid stems, brachiopods, gastropods, bryozoans and trilobites. The corals are especially abundant so that in many places it suggests a coral plantation. The fossils are calcite like that of the inclosing rock and are difficult to separate from the matrix without fracturing them. They are a little more resistant to the agents of disintegration than the matrix, become easily affected by secondary silicification and hence stand out in relief on the weathered surfaces.

The Onondaga limestone is the most durable rock in the section and hence stands out in bolder relief on the surface than any of the

Digitized by Google

Plate 5

Onondaga limestone at the north edge of the Allegheny plateau. Glacial and water-swept surface. Solution along joint planes

Digitized by Google

Digitized by Google

others. Except where buried under the floor of Onondaga valley and Butternut valley, it forms a continuous outcrop across the quadrangle. In most places it is the top layer at the northern edge of the plateau escarpment, as in the steep cliffs around the Green lake and Blue lake basins and along many of the deep depressions cut into the plateau. In many places the upper surface of this rock free from any soil covering extends over a width varying from a few feet to several hundreds of feet back from the cliff edge. The older residual material was scraped off by the glacier and the surface washed clean by the glacial waters. There has been very little disintegration from the temperature changes. Decay goes on almost entirely by solution and the rock is such a pure carbonate of lime that any slight residual matter left on the surface is washed away by the rains. As in other limestone regions, disintegration has been by the descending ground waters acting along the joint planes which have been opened up in this way into fissures varying from a few inches to several feet in width and extending down in places more than a hundred feet below the surface. These fissures in some places open up into caverns of some size. At the "Syracuse caves," 3 miles southeast of the city, some of these fissure caverns have been explored to a depth of more than a hundred feet and some hundreds of feet in length. Where this fissuring has been intensified it produces the well-known karsten topography.

In a few places there has been a little deposition of calcite on the walls of the fissures, but in general the deposition is very slight in comparison with the solution since most of the material dissolved has been carried away into the streams or deposited in the deeper portions of the underlying rocks.

Some of these fissures are open enough at the top to permit large quantities of snow to enter them during the winter months, and remain in the form of snow and ice during the greater part of the summer, forming what is known locally as the "ice caves." These occur in the cliffs around Blue lake and at the Split Rock quarries.

Overlying the lower crystalline portion of the Onondaga limestone is a thickness of 60 to 70 feet of a compact blue limestone containing many scattered concretionary masses of chert and hornstone. In the older reports this is known as the Corniferous because of the prevalence of the hornstone. The chert is very irregularly scattered through the limestone, yet it occurs in sufficient quantities and so distributed that no considerable body of the stone is anywhere entirely free from the chert, and thus it seriously injures the rock

Digitized by Google

for industrial uses such as building stone or quicklime. Still it is suitable for crushed stone and is used in considerable quantities for road and railway ballast and concrete work.

The upper portion of the limestone was formerly known as the Seneca limestone and is characterized by great numbers of a small brachiopod, Chonetes lineatus. Many of these small shells have a decided pink color. This portion of the limestone is generally free from chert but contains considerable clay disseminated through the mass so that it crumbles rapidly on exposure to the weather and hence has no economic use.

The Corniferous portion of the limestone between the Seneca and the crystalline, while it contains many trilobites and other fossils, is much less productive of organic remains than the top and bottom layers.

MARCELLUS AND CARDIFF SHALES

Overlying the Onondaga limestone is a great thickness of Devonic shales that forms the higher hills and in fact the great plateau of southern and south-central New York. Only a few hundred feet of these shales occur on the Syracuse area. The overlying higher ones appear as one goes southward over the higher portions of the plateau.

Immediately overlying the Onondaga limestone is a bed of argillaceous fissile shale about 275 feet thick. Formerly it was all classed as the Marcellus shale but recently this term has been limited to the lower part, about 100 feet in thickness, and the upper portion is called the Cardiff shale.

The contact between the Marcellus and the overlying Cardiff shale is not sharply defined. The Marcellus is typically a black bituminous shale with numerous iron carbonate concretions scattered through certain portions of it, most abundant near the middle of the bed. The carbonate concretions vary in size from a few inches to several feet in diameter, sometimes nearly spherical in shape and sometimes flattened or lenticular. Some of the concretions have been shattered and the cracks filled in, forming typical septaria. Calcite, siderite, and barite are the common minerals filling the cracks in the septaria. In places the shale is twisted and distorted around the concretion caused by pressure exerted by the growing nodule.

As indicated on the map, the Marcellus shale crops out over an area about 4 miles in length across the southwestern corner of the Syracuse quadrangle. Good exposures of it may be found in the

Digitized by Google

Plate 6

The *Karsten*, showing effect of surface and ground water on Onondaga limestone. The water dissolves the rock along the joint planes forming deep fissures which widen into caves in places. Some of these fissures extend to a depth of 100 feet or more. On top of cliff at Blue lake

Outcrop of Marcellus shale showing the numerous joint planes and the effect of the joint planes on the rapidity of weathering. The exposure is on the bank of a brook which carries away the talus as it is formed

Digitized by Google

Digitized by Google

Plate 7

Concretions in shale. The curving of the shale is due to the pressure from the growing concretion

Digitized by Google

Digitized by Google

ravines at Onondaga hill and at the reservoir near the county almshouse, a mile west of Onondaga hill.

With the exception of the Agoniatite limestone, which carries a very prolific fauna, the Marcellus shale is nearly barren of fossil remains in the Syracuse area. Fish remains have been found in the carbonate nodules.[1]

No economic use has been made of the Marcellus shale in this vicinity. It contains possibilities in the source of material for the manufacture of brick and tile, but as yet no attempt has been made to so utilize it. Considerable money and energy have been wasted in digging in this shale in different places in search of coal. The similarity in color and structure of this shale to that usually accompanying coal beds is doubtless the cause of this ancient but vain search for coal.

AGONIATITES LIMESTONE

In the Marcellus shale about 15 feet above the base is a bed of impure limestone about 3 feet thick, known as the Cherry Valley or Agoniatites limestone. The latter name is from the numerous large coiled cephalopods, Agoniatites expansus Vanuxem, found in this limestone. It is very fossiliferous at every exposure in this vicinity, containing large numbers and varieties of goniatites and other cephalopods such as Orthoceras, Cyrtoceras and Gomphoceras. This limestone is a fairly persistent bed in this locality. It is exposed in a ravine a mile west of Onondaga Hill, and on the hill above Kimber spring on the west side of Onondaga Valley. It may be seen at a number of places along the road east of Jamesville on the Tully quadrangle. This limestone extends as far east as Schoharie county and west beyond Union Springs in Cayuga county.

The Agoniatites limestone has no economic value in this region. It is too crumbly for use as building stone and contains too many impurities for use as quicklime.

CARDIFF SHALE

The Cardiff shale overlies the Marcellus without any very sharp line of separation. It is typically a bluish gray argillaceous shale grading into the black Marcellus shale below and the Skaneateles shale above. It is named from the village of Cardiff, 10 miles

[1] On some Dinichthyid armor plates from the Marcellus shale, by Burnett Smith. The American Naturalist, v. 43, Oct. 1909.

Digitized by Google

south of Syracuse, where it is about 175 feet thick. The maximum thickness represented on the Syracuse area is less than a hundred feet owing to the erosion of the upper layers. So far as known, the Cardiff shales are barren of fossils in the Syracuse area.

The higher divisions of the Devonic shales do not occur on the Syracuse area but are exposed farther south on the Tully quadrangle and are described in the bulletin relating to that region.[1]

ECONOMIC GEOLOGY

The mineral resources of the Syracuse area are varied and many of them important. They include (1) building stone, (2) crushed stone, (3) cement and lime, (4) sand and gravel, (5) gypsum and plaster, (6) clay and shale, (7) salt, (8) peat, (9) marl, (10) soil.

Many of these products have been mentioned in the preceding pages and most of them have been discussed in previous publications of the State Geological Survey. The brief account here given will serve as a local summary.

BUILDING STONE

All the limestones of the area, including the Onondaga, Helderberg, Manlius, Rondout, Cobleskill, Bertie, Fiddler's Green (Camillus) and the Lockport, have been used to some extent for building purposes. The most valuable of all for structural use is the lower or crystalline division of the Onondaga limestone, locally known as the "gray limestone." The Helderberg and Manlius blue limestones underlying the Onondaga have an extensive use for foundations, bridge piers, retaining walls, stone fences, and as crushed stone for macadamizing highways, for railway ballast, for concrete work, and with the Onondaga limestone for the manufacture of soda ash at Solvay. The underlying limestones, the Rondout, Cobleskill, Bertie, Camillus and Lockport, are all dolomitic and are all inferior to those mentioned above for structural purposes. They are used locally along the outcrops for rough building work for such structures as will not justify the expense of transporting the better stone from a distance.

All the limestones of the area are suitable for and all have been used for *crushed stone*, *concrete*, *macadam* and *railway ballast*. The largest quarries producing crushed stone for such purposes are those of the Rock Cut Stone Company in the railway channel 3 miles southeast of the city of Syracuse.

---

[1] D. D. Luther. Geologic Map of the Tully Quadrangle. N. Y. State Mus. Bul. 82. 1905.

Digitized by Google

Economic features of the Onondaga limestone. The upper, Seneca, division of the Onondaga limestone, because of its poor weather-resisting qualities, has little or no commercial importance. The middle cherty or "Corniferous portion" is used extensively for crushed stone and locally for rough building purposes such as retaining walls, bridge piers and stone fences; but the scattered chert masses prohibit its use as a stone in superstructures. There are many miles of fences built of this stone in Onondaga county where it has been used largely to get rid of the many boulders scattered over the fields. Many of these fences are now being used to furnish stone for the macadamized roads in process of construction.

The underlying crystalline portion of the Onondaga limestone is among the best building stones in the State. Its durability is shown by its strong relief on all the outcrops and in the buildings in which it has been used. The interlocking crystalline grain has destroyed to a large extent the lamination of the rock, so that under the stonecutter's tools it acts like a marble. In fact, it is only the absence of bright color that prevents its use as marble. It has the strength, elasticity and somewhat similar structure of the best marbles.

The Onondaga limestone is as easily cut or drilled as the compact limestones of the region, but its texture makes it much more difficult to break. This quality renders it not only desirable for use in the walls of buildings, but especially so for purposes where great transverse strength is required, as in trimmings, sills, lintels, curbing, sewer caps and bridge work. It is the purest lime carbonate in the region and for that reason it was long used almost exclusively by the Solvay Process Company in the manufacture of soda ash. After exhausting the available supply of this stone at the Split Rock quarries, the company opened other quarries at Jamesville where at present it is using the underlying blue limestone.

The crystalline Onondaga limestone has had a more extensive use for building stone in Syracuse and vicinity than any other rock. It may be seen in the Hall of Languages and the Steele Hall of Physics on the university campus, in the City Hall, in the old Court House, and in many of the dwellings of the city. In most of the better class of dwellings it is used for the part of the foundation exposed above the surface, while the bottom or concealed portion of the foundation is of cheaper limestone. It has been used also in the better class of farm houses and suburban residences around Syracuse, and considerable quantities have been shipped by rail and canal to other points in the State. It has had an extensive use for bridge work, culverts, sewer caps, curbing, manholes and retaining walls.

Digitized by Google

The Split Rock quarries are the largest in the county but, as already stated, the stone from these quarries was used in the making of soda ash. The largest quarries from which the stone has been taken for building purposes are on the Onondaga Indian Reservation, about 6 miles south of the city and located in the Tully quadrangle. From the reservation quarries stone for buildings in Syracuse and elsewhere has been quarried for more than a century; much of the labor in the quarries was done by the Indians.

Besides the two large quarries mentioned, there are a great many smaller ones within the Syracuse region, from which large quantities of the Onondaga limestone have been taken.

Economic features of the Helderberg and Manlius limestones. The blue limestone layers of the Manlius have had an extensive use for structural purposes in the city of Syracuse and vicinity, for foundations, retaining walls and bridge piers. Large quantities of it are crushed for use in macadamizing roads, for railway ballast and for concrete. One of the largest quarries is that of the Rock Cut Stone Company, formerly the Alvord quarry, about 3 miles southeast of Syracuse on a sidetrack of the Delaware, Lackawanna and Western Railroad. The product of this quarry is shipped by rail to more distant points. The recently abandoned quarries of the Solvay Process Company at Split Rock have produced large quantities of the Manlius limestone in connection with the overlying Onondaga limestone. Other quarries in this rock are Britton's 2 miles south of the city; the Russell quarries at East Onondaga 2½ miles south; Dunlop's quarry; the Penitentiary quarry; and the new quarries of the Solvay Process Company at Jamesville, and numerous others at Fayetteville and Manlius and along the escarpment west of Onondaga valley. In fact there is an almost continuous chain of quarries in this stone across the Syracuse quadrangle.

The Manlius limestone has also been used for the making of quicklime at many places in the vicinity. Besides the continuous kilns located at many of the quarries above mentioned, there are numerous temporary kilns at many places along the outcrop. Most of these are abandoned now and at present very little quicklime is manufactured in this vicinity.

CEMENT AND LIME

While cement or hydraulic lime can be made from nearly all the argillaceous dolomites of the area, the two waterlime layers in the upper part of the Manlius group are so superior to the others that they are used almost exclusively for this purpose in the Syracuse

Digitized by Google

area. They consist of a mixture of clay and the carbonates of lime and magnesia in about the right proportions to make a strong quick-setting hydraulic cement when burnt and ground. In portland cement the materials are mixed by man; in the waterlimes the mixing was done by nature in the deposition of the materials. The Manlius waterlime has been quarried and used in this area for nearly a century. It was first used extensively in 1821 in the construction of the Erie canal through this county. Owing to the great expense involved in removing the overburden the quarries are generally small and do not extend far back from the outcrop of the stone, but the quarries are numerous and form an almost continuous line across the quadrangle and beyond. The largest quarries are near Jamesville, Fayetteville and Manlius and the mills for grinding the cement are located in or near these villages.[1]

Quicklime for local use has been produced at many different points along the limestone outcrop. Both the large continuous kilns and the smaller intermittent kilns have been used for this purpose. The best quicklime is obtained from the blue Manlius, Helderberg and Onondaga limestones. The production of both the lime and the cement has nearly ceased in this area at the present time.

GRAVEL AND SAND

Gravel and sand are now used in ever increasing quantities in construction work, not only in mortars and masonry, but also in concrete in the foundations for buildings, roads and different engineering operations. The largest and best supplies of these materials are taken from the postglacial terraces which extend for miles along the sides of the Onondaga valley in and south of the city. Many pits large and small have been opened in these terraces on both sides of the valley. In some places sand alone is obtained, in other places gravel, and sometimes the sand and gravel occur together and are separated by screening at the pit or at the place where it is used. Besides the terrace deposits, there are vast quantities of both sand and gravel underneath the floor of the valley. The Onondaga valley has been filled in to a depth of several hundred feet and much of this filling consists of sand and gravel. Numerous pits have been opened in various parts of the city from which these materials have been taken out.

---

[1] For further particulars see 49th Rept. of N. Y. State Mus., 1895, p. 237–315.

Digitized by Google

GYPSUM

Gypsum, the hydrous sulphate of calcium ($CaSO_4$, $2H_2O$) occurs in large quantities on the area of the Syracuse quadrangle and the adjoining areas to the east and west. As its locus is in the Camillus shales, its distribution in the area is indicated on the map by the outcrop of the Camillus group. While it occurs at several different horizons in the shales, the largest and most continuous bed is at the top of the series immediately underlying the Bertie dolomite. Nearly all the gypsum quarries will be found along the line of contact of these two groups, the Bertie and the Camillus.

The maximum thickness of the gypsum in the area is reached in the quarries a mile south of Lyndon near the southeast corner of the quadrangle, where it has a thickness of 60 feet from which it varies to about 20 feet near the southwest corner of the map. The deposit is not all pure gypsum but contains carbonates and argillaceous material ranging from 1 or 2 up to as high as 20 per cent of the mass. The impurities are rather intimately mixed through the deposit, and the clayey matter appears to make up a larger percentage of the mass than it really does.

There is sufficient quantity of impurities in the gypsum to discolor it and make it unfit for finishing plasters, but the impurities do not seriously injure it for use in portland cement and land plaster. In the early days of the industry in this region nearly all the product was used for land plaster, for which purpose it was ground into a fine flour before being applied to the soil. Mills for this purpose are located at Jamesville and Fayetteville, but they are falling into disuse as less and less of the gypsum is being used for this purpose and more of it is being used in the cement industry.

The gypsum is added to portland cement as a retarder to prevent the cement from setting or hardening too quickly. While only a small percentage ($2\frac{1}{2}$ per cent or less) of gypsum is used in the cement, the aggregate amount so used is large owing to the enormous consumption of cement which has increased tremendously in the last one or two decades. It is for this purpose that much of the gypsum now quarried in this county is sold.

The most important application of gypsum of course is in the manufacture of wall plasters, in which it is replacing the lime mortar formerly used almost exclusively for this purpose. It is not only used as a mortar to apply directly to the wall, but some of it is made up into thin sheets with layers of paper, known as plaster board, which is nailed to walls and ceilings and does away with lath. A thin coat of plaster is put on top of the plaster board

Digitized by Google

to cover the cracks and the nails. Plastered in this way, rooms are habitable as they are finished and the builder does not need to wait months or weeks for the dampness to get out of the wall. Various substances are mixed with the gypsum when used for plaster, some simply as coloring matter and some for other purposes. These mixtures are patented and sold in the market under the patented name.

The largest gypsum quarries are in the area south of Lyndon in an outlier separated from the Alleghany plateau by an east-west glacial channel extending through White lake. Some of these quarries have been in operation for a century and the supply is not yet exhausted. There are numerous abandoned quarries along the north edge of the plateau escarpment between White lake and Jamesville; in fact, it is almost one continuous quarry between these two points. The gypsum has been quarried on the outcrop back into the plateau until the thickness of the overlying rocks became so great that the expense of the removal of the overburden prevented further quarrying with profit. In a few places the attempt has been made to mine the gypsum underground without removing the overlying rock, but so far this has not proved very successful. Some gypsum has been quarried along the Delaware, Lackawanna and Western Railroad east of Butternut creek. The gypsum extends both east and west from the Syracuse area but in this locality most of the product has been derived from the area mentioned between Butternut and Limestone creeks in the southeastern part of the quadrangle. The bed is probably continuous to and beyond the quarries at Union Springs.

SALT

The Camillus shales contain the great beds of rock salt of central and western New York. The names Salina and Onondaga salt group in the older reports indicate the prominence of the salt in this locality; both of these terms, however, include the underlying Vernon shales as well as the Camillus. They were long known locally as the lower Salina red shales and the upper Salina gray shales. While some salt is reported to have been found in the red shales, it is the gray or drab colored Camillus shales that contain the commercial salt beds. The abundance of salt in this group explains the absence of fossils as the concentrated salt water and the arid conditions necessary to produce the same are inimical to both animal and vegetable life.

The larger salt beds occur near the base of the Camillus group in this locality, but there is seldom any salt in the solid form in

Digitized by Google

the shales in the city of Syracuse or on the Syracuse quadrangle, or, in fact, anywhere else on or near the outcrop; because the salt is so soluble in water that near the surface it has all been leached out

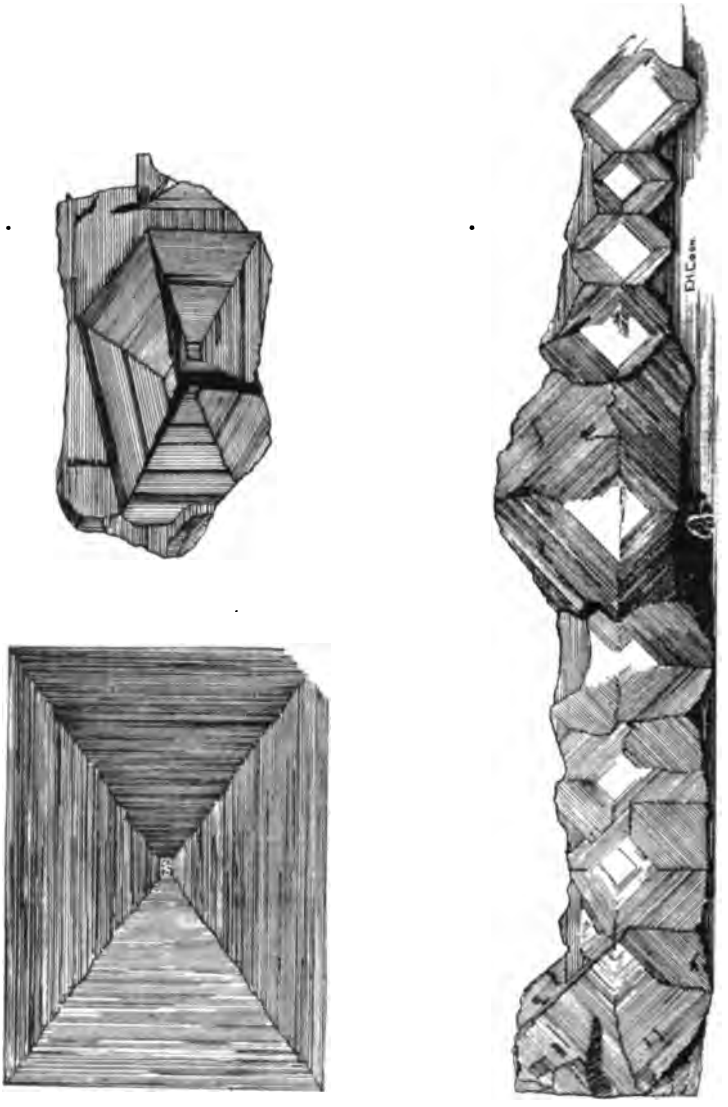


Fig. 2 Hopper casts of fossil salt crystals

by the percolating ground waters. The position in the Salina series of the salt beds as determined by the wells and shafts which penetrate the beds of rock salt, is called the *Syracuse salt horizon.* That salt formerly occurred in the now outcropping portion of the shales

Digitized by Google

in the city is shown by the great number of casts or hopper-shaped imprints of the salt crystals. Under favorable conditions these hopper-shaped crystals were formed several inches in diameter.

The leaching out of the salt permitting the settling of the overlying beds would cause considerable disturbance in structure of these beds. Some folding and faulting does occur but apparently much less than one would expect, from which the inference is drawn that the salt beds probably were never so thick at Syracuse as they are farther south and west.

The salt industry at Syracuse is older than the city. Even before the days of the pioneers salt was obtained here by the Indians and the Jesuit missionaries, and since the first settlement by the whites the industry has been a continuous one. The first salt was obtained by boiling the water from the salt springs. When the springs failed to furnish a sufficient supply, wells were sunk and the water pumped to the surface. These wells are sunk in the sands and gravels on the flat at the east end of Onondaga lake where the water was found to be salty but no rock salt was found. The wells range in depth from 80 to 340 feet. To settle definitely the question whether or not salt occurred in solid beds under the area, two wells were drilled in 1884 to depths of several hundred feet. The State well was drilled at the south end of the lake and the Gale well on the east side of the lake; the former was sunk to a depth of 1600 feet and the latter 1969 feet, but no rock salt was found in either one of the wells. In the latter, brine was found at 485 feet, 532 feet, 1395 feet and 1500 feet.

It was long suspected by geologists that the salt in the brine springs and the wells at Syracuse was leached by the ground waters from beds of salt south of the city where they were protected by a great thickness of overlying rocks from the rapid action of the surface water. The existence of such beds was proved by the borings of the Solvay Process Company in the Onondaga valley south of the city. This company sank a well in 1881 at Jamesville to a depth of 1040 feet and abandoned it without finding rock salt. In 1882 they sank a well at Cedarvale about 10 miles southwest of the city to a depth of 1157 feet. Brine was obtained at a depth of 500 feet but no rock salt. In 1888 the company put down another well said to be near the center of the valley. This well was abandoned at a depth of 400 feet because the tube collapsed in a bed of quicksand. The next well was bored 1400 feet east of the latter and in this a bed of rock salt was struck at a depth of 1216

Digitized by Google

feet. The first salt bed 45 feet thick was followed by 25 feet of shale and then came a second bed of salt 54 feet thick. The next well was sunk about 4 miles farther north and about 1 mile south of Cardiff and was abandoned at a depth of 844 feet. Since that time the company has sunk many wells near the south end of the valley, finding rock salt in all of them. The salt occurs in several different beds separated by varying thicknesses of shale. The maximum total thickness of salt here found is 318 feet and the maximum thickness of a single bed is 74 feet.

Owing to the great depth of these beds, 1000 feet and more below the surface, the salt is not mined in the solid state, but water is run into the wells, the salt dissolved and pumped out in solution. The brine is then run by gravity through a pipe line to the soda works at Solvay where it is used in the manufacture of soda ash and various sodium compounds.

In the early days of the salt industry at Syracuse, all the salt was obtained by boiling the brine in kettles. The single kettles were in time followed by blocks of 60 or 70 kettles arranged in double rows and heated from a single fire. Some of these kettles were large enough to hold 150 gallons of brine. Many of them may now be seen in the region around Syracuse where they are used as watering troughs. In 1858 there were 312 salt blocks with 16,434 kettles of 90 to 150 gallons capacity. The kettle-boiling process was gradually abandoned and the solar process used more extensively. By the solar process the brine is evaporated in shallow wooden vats by the heat of the sun in the summer season, the vats not being operated in the winter. By this process a coarse salt used largely in meat packing and refrigeration is produced. By the kettle process a finer quality of table and dairy salt is made.

From 1797 to 1904 there were 430,000,000 bushels, or over 12,000,000 tons, of salt produced in the yards around Onondaga lake. The maximum output was in the year 1862 with 9,530,874 bushels. The wells were formerly owned by the State, which exacted a small royalty from the manufacturers, based on the amount of salt produced, but they were recently transferred to private ownership.

SWAMP AND LAKE DEPOSITS

PEAT, MUCK, MARL AND CLAY

In the lake basins and swamp areas of the Syracuse region are quite extensive accumulations of vegetable, animal and mineral matter of considerable economic importance. They have been

Digitized by Google

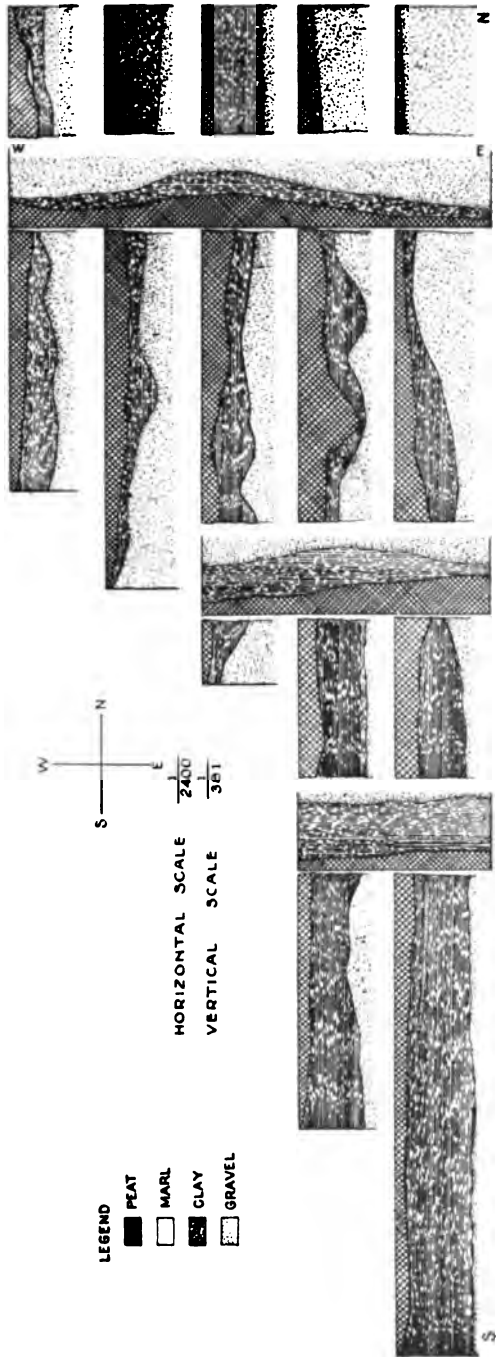


Fig. 3 Vertical sections across Cicero swamp

Digitized by Google

utilized very little as yet and the extent of the deposits below the surface is largely a matter of conjecture.

A systematic examination of a portion of one of the larger swamp areas of the region was made during the fall and winter of 1912 by two of the graduate students of Syracuse University.[1] In the course of the examination numerous borings were made by means of a clay auger through the swamp deposits to the underlying gravel. The borings were made at intervals of 100 feet along five north and south lines 300 feet apart. These north-south lines across the swamp varied in length from 1400 to 4300 feet, making in all 128 bore holes. From the hundreds of samples thus collected the character and extent of the deposits in this area were determined with a great degree of accuracy.

The results of the investigation showed at the surface of the area a bed of peat varying from 1 to 31 feet thick; thinnest at the margin and increasing toward the middle, but reaching a maximum north of the middle of the swamp as shown on the accompanying diagram. The clay underlying the peat is thinner near the middle of the swamp and thicker toward the margin, with the greatest thickness on the south side at the wider portions of the swamp.

The peat in the area studied is of dark granular material to a depth of 4 feet, below which to a depth of 10 feet it is more fibrous and compact. At the bottom it contains so much water that it forms a semifluid black muck. A sample from the surface of the peat gave 61.44 per cent moisture and one from a depth of 10 feet showed 84.275 per cent. Several tests for calorific value gave an average of 8448 B.T.U. Tests for ash gave an average of 5.12 per cent.

The light colored clays underlying the peat vary considerably in composition. A partial analysis was made of some two dozen samples from different parts of the area, the average of which was 70 per cent insoluble in dilute hydrochloric acid, 20 per cent calcium carbonate and 8 per cent alumina and iron oxid. The insoluble part ranges from 68 to 84 per cent and in one sample as high as 94 per cent. It consists of silica and insoluble silicates which were not analyzed separately. The calcium carbonate varies from 10 to 25 per cent; and the soluble alumina and iron oxid from 4 to 9.6 per cent, mostly alumina as the iron content was so slight that no

[1] The results of their exploration and study are placed on record in a thesis for the master of science degree at Syracuse University. The names of the men who did the work are Arthur E. Brainerd and Clinton W. Perry.

Digitized by Google

attempt was made to separate it. The source of this white clay is one of the most puzzling problems in the local geology. The great thickness and extent of the deposit rather taxes the imagination to ascribe it entirely to the leaching out of the coloring matter by the growth and decay of the organic matter of the overlying peat beds, especially so since most of the vegetable matter is of plants with small roots. The alternative views are almost equally taxing on the imagination, namely, that it is due (1) to a gradual accumulation of the clay, or (2) to the downward percolation of the swamp water through the bed of clay. Favoring the last view is the fact that the clay is everywhere underlain by a bed of gravel, but opposed to it is the character of clay which is so impervious to the movement of water that it would require such a long period of time.

No attempt has been made as yet to utilize this white clay, probably due to the fact that its existence is unknown to the industrial world. So far as known to the writer, this is by far the largest body of light colored clay in the State of New York.

In nearly all the other swamp areas in this region the peat is underlain by shell marl so far as their contents are known. This shell marl is composed of the remains of small calcareous shells which are still accumulating rapidly in many of the shallow lakes in the region. No systematic examination has been made of the marl deposits in the immediate vicinity of the city. Similar marl deposits were exploited and used in large quantities at the village of Warners, 15 miles west of Syracuse, in the manufacture of portland cement. The cement plant at Warners was abandoned some years ago and at present no marl is used in this portion of the State.

CLAY AND SHALE

Besides the bed of white clay in the Cicero swamp, there are many other clays and shales in the region. The surface clays have been utilized in a number of places in the manufacture of red building brick and tile, and to some extent for paving brick.[1]

The red Vernon shales have been utilized in the manufacture of brick at Belle Isle near the west margin of the quadrangle, near Kirkville in the east portion of the quadrangle, and at Warners 15 miles west of the city of Syracuse. There is an unlimited amount of this shale convenient to rail and canal transportation.

[1] Economic Geology of Onondaga County. 22d Ann. Rep't State Geol. N. Y. 1902. p. 109.

Digitized by Google

The other shales of this region, the Camillus, the Marcellus and the Cardiff, have possibilities as a source of material for the manufacture of brick and tile, but as yet none of them have been utilized.

SOILS

The soils of the Syracuse area were mapped and described by the United States Department of Agriculture in 1903.[1] This report shows thirteen kinds or classes of soils distributed over the area, as follows:

	ACRES
Miami stony loam	78 464
Miami silt loam	41 536
Miami gravelly loam	39 424
Miami fine sandy loam	19 968
Miami fine sand	14 528
Miami loam	9 728
Alloway clay	24 832
Muck	16 960
Swamp	12 480
Penn clay	3 840
Alton stony loam	3 712
Made land	576
Warners loam	128

The soil map referred to is twice the size of the map accompanying this report. It includes the area of both the Syracuse and Baldwinsville quadrangles of the United State topographic atlas.

The agricultural interests of the area are somewhat varied as are the soils. The dairy interests probably stand first in importance; truck gardening and fruit raising are both important. The rather steady growth of the manufacturing interests in and near the city increases the farming industry by furnishing better home markets.

STRUCTURAL GEOLOGY

The rocks of the Syracuse area are sediments formed in the Paleozoic sea, the shore of which was to the north and east. In the uplift of the area above sea level there was a greater elevation of the old landward side than of the new sea bottom areas which caused a tilting or inclination of the strata toward the south and west. There were probably several periods of uplift and depression, the algebraic sum of which is the present position of the rock

[1] Soil Survey of the Syracuse Area, by Bonsteel, Carter and Ayres. Field Operations of the Bureau of Soils, 1903, published in 1904.

Digitized by Google

Plate 8

A sharp fold in the Onondaga limestone. The layers where the man is standing are nearly vertical. A short distance to his right and left they are nearly horizontal

Digitized by Google

Digitized by Google

beds. While the rocks in most places appear to the eye to be nearly horizontal, if one follows a stratum a short distance north or south, it will be seen to have a marked dip to the south. Hence as one travels north across the area he passes over the outcropping edges of successively older rocks which dip underneath all the newer ones to the south.

In a few places the strata are rather sharply folded and in several places fractured and faulted. The most marked disturbances of the strata follow a nearly east and west direction near the north edge of the plateau and nearly parallel with the edge. The line of disturbance is not a straight one nor is it known to be continuous. It is probably not. The most easterly point at which this disturbance has been observed is near the Seneca turnpike between Jamesville and Manlius near Fillmores Corners. In the channel of a small brook south of the turnpike the Onondaga limestone is bent in a monoclinal fold almost at right angles, as shown in the accompanying view (plate 8). The continuation of the fold eastward is shown in the next ravine and it appears again on the roadside a quarter of a mile west in a cutting in the Marcellus shale.

The disturbance is shown by several thrust faults at Fiddler's Green. There are two faults with the overthrust to the north in the gorge below the falls and two others in the cutting made for the trolley line at the north end of the gorge. The displacement varies from a few inches to about 4 feet. (Plates 9 and 10.)

At Russell's quarry 4 miles west of Fiddler's Green at the southern edge of the Syracuse quadrangle and the north margin of the Tully quadrangle, there is a thrust fault in which the Manlius limestone is thrust northward over the Onondaga and Oriskany. The vertical displacement is 42 feet. At the south end of the quarry there is a sharp monoclinal fold to the south in the Manlius limestone. Half of a mile north of Russell's quarry there are several small thrust faults in the Fiddler's Green limestone in the railway cut.

There are some horizontal faults in the Onondaga limestone at the quarries on the Indian reservation 3 miles south of Russell's quarry. In an abandoned limestone quarry on the hillside southwest of Elmwood the rocks are bent and fractured in a somewhat complex manner.

In Maylie's quarry, a mile southeast of Marcellus on the Skaneateles quadrangle, there is a thrust fault with a vertical displacement of 3 feet.

Digitized by Google

It is possible that similar faults to those mentioned occur on the area north of the plateau escarpment, but their existence is not known. The covering of mantle rock is so continuous and the exposures of the rock so limited in number and size that no fault planes have been observed; they may or may not be present.[1]

IGNEOUS ROCKS

At several places in the city and in the vicinity molten rock was forced up from the deeper portions of the earth through cracks or fissures to or near the surface, forming dikes of igneous rocks. One of these dikes in the city is exposed on Green street near Lodi and has been traced by means of excavations for a mile or more from that point through the city. If it were not for the heavy covering of mantle rock concealing it, it could probably be traced much farther. The excavation for the Dewitt reservoir a few miles east of the city is in a dike of igneous rock similar to that on Green street. These peridotite dikes and others of similar character are described in the following pages in a paper by B. W. Clark on the *Peridotite Dikes of Central New York.*

PHYSIOGRAPHIC FEATURES

The physiographic features of the Syracuse region, while quite varied in character, are all comprised in two of the great physiographic regions of the State, namely, the Alleghany plateau on the south and the Ontario lake plains on the north. There is sufficient complexity of detail in each of these regions to give variety and interest to the scenic features, some of which are quite striking. The greater part of the Syracuse area is on the lake plains; only a small fraction along the southern margin catches the northern edge of the plateau.

Since the northern edge of the plateau has been beveled by the ice and other weathering agencies, the part on the Syracuse quadrangle does not nearly reach the maximum height of the plateau. The highest point on the quadrangle is a little over a thousand feet above sea level, while farther south the plateau rises to about three

[1] For further account of these faults and folds, see Luther, Economic Geology of Onondaga County. 15th Ann. Rep't N. Y. State Geologist, 1895. Also P. F. Schneider, Note on some overthrust faults in central New York. Am. Jour. Sci., v. 20, Oct. 1905, and The Marcellus Fault, Onondaga Academy of Sciences, 1899.

Digitized by Google

Plate 9

Fault plane in the gorge at Fiddler's Green, near Jamesville. Thrust fault. Note the curving of the ends of the layers at the break

Digitized by Google

Digitized by Google

Plate 10

Thrust fault in the Fiddler's Green (Camillus) limestone along the electric line 200 yards north of Fiddler's Green station

Digitized by Google

Digitized by Google

Glacial channel or gorge cut in Manlius limestone by glacial waters 2 miles south of Fayetteville

Digitized by Google

Digitized by Google

times this elevation. The lowest point on the area is 360 feet, thus giving a maximum relief on the area of the quadrangle of approximately 640 feet.

CHANNELS

The northern edge of the plateau is a somewhat bold limestone escarpment very irregular in contour. The north-flowing Onondaga and Butternut creeks have cut deep valleys or trenches in the plateau, thus dividing the escarpment on this quadrangle into three parts. Smaller streams have cut notches between the larger creeks thus giving the escarpment a jagged as well as broken appearance.

In addition to the north-south valleys, the north end of the plateau is diversified by a number of east-west valleys or trenches across the interstream areas, some of which are of considerable size and interest; some of them near the escarpment have separated considerable masses or outliers from the plateau, thus adding to the diversity of the relief.

The peculiar interest attached to the east-west valleys is that they were formed in large part by temporary streams sometimes of large size during the closing part of the Pleistocene glacial period and thus become fossil pleistocene channels. During the recession or melting away of the continental ice sheet, there came a time when the southern end of the ice was in the vicinity of Syracuse and the waters from the melting ice and from the plateau having no outlet northward through the St Lawrence valley as at present, found an escape eastward through the Mohawk valley. This eastward flow from the Onondaga valley to the Butternut and from the Butternut to the Limestone valley caused the erosion of a number of deep channels across the ridges separating the north-south valleys. The first of these channels formed on the area of the Syracuse quadrangle is about 3 miles south of the city and over 1 mile north of Jamesville. It is known locally as the Railway channel, as the Delaware, Lackawanna and Western Railroad passes through it. The channel is about 3 miles long and a quarter to a half of a mile wide. The floor of the channel is 150 to 250 feet below the level of the plateau in which it is cut and the western end is 150 feet above the bottom of the Onondaga valley and the eastern end about 80 feet above the level of the Butternut valley. It thus forms a unique type of hanging valley, that is, one that hangs at both ends.

During the time when the water was flowing eastward through the Railway channel, the ice front was probably near the north bank

Digitized by Google

of the channel. As the ice front retreated northward it permitted the escape of at least part of the waters through another channel half of a mile north of the Railway channel. Later part of the waters passed north of east through a shallower channel crossing the southeastern part of the city of Syracuse, and still later the waters passed eastward through the central part of the site of the city, through the depression now followed by the Erie canal and the New York Central Railroad.

While the channels mentioned were being formed through the divide separating the Onondaga and Butternut creeks, other contemporaneous channels were in process of formation west of Onondaga creek and east of Butternut creek, in the southwest and southeast portions of the area of the Syracuse quadrangle.[1]

TERRACES

During the period that the channels were being cut by the east-flowing waters, the north-south valleys, such as the Onondaga and the Butternut, would be partly filled by the impounded waters forming temporary lakes in which the water would stand at successively lower levels as the lower cross-channels were opened one after the other. Where such lakes remained at the same level for a considerable period of time, more or less well-defined shore features would be developed, especially sand and gravel terraces. Besides their interest as topographic features, these terraces are important commercially as from them are obtained the large quantities of sand and gravel required in structural work in and around the city.

The terraces occur at several different levels, at least five fairly distinct ones appearing on the higher hills south of the city. On the area of the Syracuse quadrangle the most prominent terrace is near the level of the 500 foot contour above sea level. It shows on both sides of the Onondaga valley but is more prominent on the east side. It marks the west margin of the Syracuse University campus. Eastward from the campus through the city it has been largely obliterated by building operations, but southward it is nearly continuous as far as the Indian reservation. Large quantities of sand and gravel have been removed from this terrace at the Calthrop residence on South Salina street, at Kelley's coal yard on the Delaware, Lackawanna and Western Railroad and other points. On the west side of the Onondaga valley this terrace is quite promi-

[1] For further details of the surface geology of this region, see the various papers by H. L. Fairchild published as bulletins of the N. Y. State Museum.

Digitized by Google

In the glacial cross channel a mile west of Elmwood. Looking down the channel. The mound in the middle of the picture lies in the channel near the north side. The north bluff shows through the tree at the left. The south bluff is terraced and covered with forest growth on the right

Digitized by Google

Digitized by Google

Plate 13

In the Burnet park cross channel looking west from site of the House of Providence

Digitized by Google

Digitized by Google

Plate 14

View from the hill about the Onondaga Indian Reservation, looking northwest across Onondaga valley showing the extensive sand and gravel terrace on the west side of the valley

Digitized by Google

Digitized by Google

nent from Hopper's glen southward by Dorwin spring and through the Indian reservation.

The hill in the north part of the city of Syracuse north of the Erie canal was an island in the glacial Lake Iroquois, and the shore terraces of the extinct lake are quite prominent on the north and west side of the hill. A gravel pit a few blocks northeast of the Wolf street car barns shows the beach structure of the terrace (pl. 15).

Terraces probably of a little more recent date show distinctly along the south side of Oneida lake.

LAKE PLAINS AND DRUMLINS

From the plateau ecarpment northward, the area is a somewhat variegated plain stretching to the shore of Lake Ontario and known as the Ontario Lake plain. The area on the Syracuse quadrangle is part of a large area stretching west beyond the Niagara river and eastward until it merges into the plain of the Mohawk valley. Scattered over this lake plain are a few outliers of the plateau, one of which is the hill in the north part of the city of Syracuse, and a great many oval-shaped hills known as drumlins.

Most of the drumlins lie west of the Syracuse area but there are a few in the city and east of the city. On the plains west and northwest from the city there are scores of these drumlins. One of the drumlins known as Mount Olympus occurs on the southern margin of the university campus and several others east and southeast of the campus.

The surface of the drumlins in the Syracuse area consists of a reddish till or boulder clay derived in large part from the outcrop of the Vernon shale. The north end of the drumlin on the campus has been cut away in the building operations of the university and shows a bedrock core of the drab colored Camillus shales. To what extent the other drumlins of the area have rock cores, constituting what are known as rocdrumlins, is not known.

HYDROLOGY

The area of the Syracuse quadrangle all drains through the Oswego river into Lake Ontario. The central and southwestern part of the area drains into Onondaga lake through Ley, Onondaga and Ninemile creeks and their tributaries and thence into the Seneca river, the junction of which with the Oneida river forms the Oswego river. The southeastern part of the area is drained by Butternut

Digitized by Google

and Limestone creeks which flow into Oneida lake and thence through the Oneida river to the Oswego river at Three River point.

The divide between the Onondaga lake drainage and that of Oneida lake is only a few feet above either lake in some places. It would be close to a line drawn from a point north of the middle of the west margin of the map in a southeastern direction to near the middle of the east margin and thence southwesterly through the southeastern part of the city and then south to the middle of the southern margin.

The area contains part of Oneida lake, the largest lake in the State of New York, all of Onondaga lake and two small lakes, White lake and Evergreen lake, in the southeastern corner of the quadrangle. There are also several artificial ponds or reservoirs on the area.

The area lies near the eastern end of the Finger Lake district of New York. Of the Finger lakes, Onondaga and Oneida are the only ones that lie wholly on the lake plains, the others occurring in depressions in the Alleghany plateau. Hence these two lakes are much shallower than any of the other Finger lakes. Onondaga lake is 5 miles long, 1 mile wide and 66 feet deep. Oneida lake is 22 miles long, 6 miles wide and 60 feet deep.

There are numerous small springs and seepages that help supply the water for the lakes, swamps and streams. Much of the spring water is classed as hard water because of the large quantities of carbonate of lime carried in solution. Considerable quantity of the lime carbonate in the form of calcareous tufa has been deposited in places by these calcareous springs. Extensive deposits of shell marl in lakes and swamps indicate the great quantities of lime carried in solution. Some of the best known springs in the vicinity of the city are Kimber and Dorwin springs on the west side of Onondaga valley and Rockwell springs on the east side of the valley (on the Tully quadrangle). There are many calcareous, sulphur and chalybeate springs east, west and south of the city.

As indicated by the numerous springs, lakes, swamps and streams, the water table lies near enough to the surface to be easily accessible for wells all over the area. Any place not accessible to the water pipe lines of the city or villages or to good springs can obtain a local supply of water from wells. The wells producing the most copious supply of water will be those which reach the water table in beds of sand or gravel in the mantle rock in the bottom of the valley or on the lake plains. Wells sunk in the bedrock will vary in the

Digitized by Google

Plate 15

Gravel pit near the Wolf street car barn, showing beach structure on the shore of glacial Lake Iroquois

Digitized by Google

Digitized by Google

"Mt Olympus," a drumlin on the Syracuse University campus

Digitized by Google

Digitized by Google

supply of water as the strata differ in porosity, but none of the strata in the area are exceptionally good aquifers so that the supply of water from many of the wells is limited, yet for the most part sufficient for household and farm purposes.

Deep wells in the middle portions of Onondaga valley will get salt water similar to that in the wells at the east end of Onondaga lake.

THE PERIDOTITE DIKES OF SYRACUSE AND VICINITY [1]

There are several localities in central New York in which dikes of basic rock cut through the Paleozoic sedimentaries. There is such a dike in the city of Syracuse, one at the Dewitt reservoir, 3 miles east of the city, another near Otisco lake, some 15 miles southwest of the city. Other dikes somewhat similar to these are known to occur near Itahaca farther to the southwest and at Manheim farther to the east.

The occurrence of these dikes in the midst of the great area of Paleozoic sediments far removed from any volcanic or batholitic areas have naturally aroused considerable interest. The Syracuse dikes are here described, brief notice is taken of the other localities, and the bibliography aims to cover all the literature available relating to the different dikes. The literature of the subject is listed chronologically at the end of the chapter and numbered serially. Reference to these papers in this chapter is given by the serial number.

HISTORICAL

The Syracuse peridotite dike, commonly known as the Green Street dike, was discovered in 1837, by the late Professor Oren Root of Hamilton College, at that time principal of the Syracuse Academy. He recognized the rock as a serpentine and brought it to the attention of Lardner Vanuxem who was then engaged upon the geological survey of the Third District. Vanuxem's description of the dike in his report on the Third District of New York, 1839 (1), is the first mention of it in geological literature. He there says: "The green and traplike rocks observed near the top of the hill to the east of Syracuse, have been examined so far as time would

[1] Much of the material for this chapter was collected by Burton W. Clark and presented by him in a thesis for the M.S. degree at Syracuse University in 1908. The dikes near Clintonville were discovered after his thesis was written. I am responsible for the form and arrangement as here presented. T. C. H.

Digitized by Google

admit. They are all serpentine, more or less impure, and of various shades of bottle green, black, gray etc. They all produce sulphate of magnesia by oil of vitriol. These serpentines are at least new varieties for our country. Some have a peculiar appearance like bronze, owing to the small goldlike particles, with a lamellar structure, resembling bronzite or diallage metalloid. Also other particles highly translucent, like precious serpentine, with frequently small nuclei resembling devitrifications or porcelanites, colored white, yellow, blood red, variegated etc. The grain of this kind is like common serpentine. In other kinds, the mass seems to be made of small globuliform concretions, varying in size, being centers of aggregation; some are of dark vitreous and serpentine, others of the compact kind, the enveloping part of a light color. The first impression of this rock is like some of the New Jersey trap rocks, where amphibole is in imperfect crystals, or like pyroxenic lava, with its imperfect crystals embedded in the more compact material.

"These two principal varieties produce endless mixtures upon the small scale, to say nothing of those derived from the difference of shades of color, the presence of veins and mixtures with the associated shales."

"These serpentines seem to resemble the ophiolites of Tuscany and Florence, and should the views of Brocchi be correct, they must not only be similar in origin but in age."

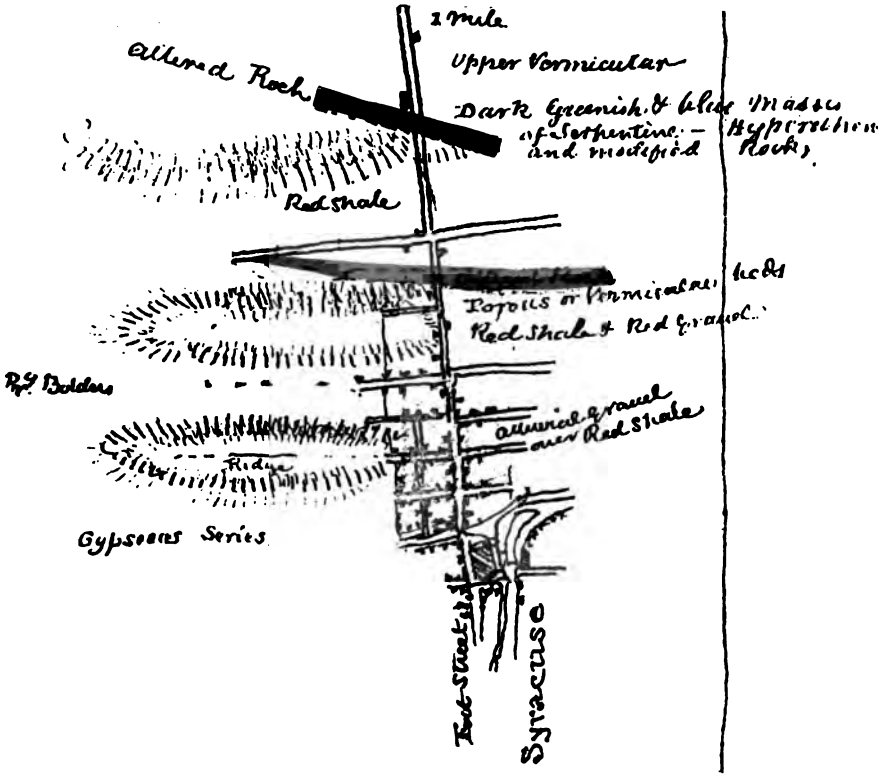
Vanuxem in his final report in 1842 (2) again describes this rock under metamorphic rock and says: "The great interest of all these metamorphic products is that they have not been caused by a dry heat or fire, no evidence of the kind existing; nor is any needed to effect the change there observed, though it can, and has, and does produce the same results. All that is required, is the presence of the elements of the products observed at Syracuse, and in a state admitting of solution and of moisture, to which every degree of heat added, would greatly aid their mutual action upon each other; and from solution crystallization would take place, and thus metamorphic products or rocks would be formed, no igneous action commonly so-called being requisite, but a thermal one only."

In the same year as Vanuxem's final report, 1842, Lewis C. Beck in his Mineralogy of New York refers to this dike under the caption *Serpentine* and quotes from Vanuxem's report.

In 1858 Dr T. Sterry Hunt (History of Ophiolites (4)) says: "At Syracuse, the strata between the two beds of porous limestone just described, are much altered; the shales are rendered harder,

Digitized by Google

Plate 17



A sketch of the serpentine dikes at Syracuse, copied without change from a field notebook of the New York State Geological Survey, 1841, and drawn by R. C. Taylor, an English geologist who accompanied the State geologists during that field season. It will be observed that in this sketch two dikes are represented, although at the present time but one is known.

Digitized by Google

Digitized by Google

and some portions of the calcareous rocks have become crystalline and are filled with crystals of celestite and calcite, while other beds are converted into a calcareous ophiolite. . . . I found a portion of this ophiolite in powder to be readily attacked by acetic acid, which dissolved a large amount of carbonate of lime, besides a little magnesia, and traces of alumina and iron. The analysis of the serpentine gave me: silica 40.67; magnesia 32.61; protoxyd of iron 8.12; alumina 5.13, and water 12.77."

So far as known, this is the first analysis made of this rock.

Doctor Hunt describes this rock as metamorphic. He says: "Ophiolites have generally been regarded as intrusive rocks. In southern Europe they occur in injected masses traversing the disrupted nummulitic strata, but they are also found in the same region interstratified with limestones, and with micaceous, chloritic and talcose schists which are regarded as altered Triassic strata. In North America the ophiolites of the Laurentian, Silurian and Devonian formations are all apparently magnesian sediments which have been metamorphosed *in situ* and never so far as I am aware assume the form of intrusives. . . . I have already shown that the action of a solution of alkaline carbonate at a slightly elevated temperature upon mixtures of earthy carbonates and quartz suffices to convert the bases of these into hydrous silicates. The same agent has at the same time given rise to the feldspar and mica of the associated strata."

George Geddes (5) in his Report on the Geology of Onondaga County in 1860 described the dike rock as follows: "There are two masses of this vermicular rock, one low down, of about 20 feet in thickness, appearing on James street, Syracuse, and at various other places; the upper mass is thinner but its thickness is not uniform. In the lower mass on James street, are some specimens of crystalline character, being serpentines, the action of crystallization having been very powerful but local, producing mica, and even nodules of granite, or rather syenite."

The next mention of the dike was by Dana in the second edition of his Manual of Geology, 1875, (6) in which he says: "Near Syracuse, there is a bed of serpentine in this formation (Salina), along with whitish and black mica, and a granitelike rock, in which hornblende replaces the mica, making it a syenite; there is little evidence of heat in the beds adjoining these metamorphic rocks. (The position of this locality is not now known)." The same statement is made in the third edition but omitted from the fourth edition.

Digitized by Google

George H. Williams published a preliminary account of this rock in March 1887 (9) and in August of the same year he gave (10) the most complete account up to this time. He showed that the rock was not metamorphic in origin but a peridotite dike of igneous origin. In his article he says: "The main points of evidence, therefore, that the serpentine at Syracuse was originally an igneous and intrusive rock, belonging to the family of peridotites, are as follows: (1) the structure of the rock, which is such as is only known to be produced by crystallization from a molten magma; (2) the existence of a more granular and porphyritic modification, as is so often the case in eruptive dikes; (3) the inclusion in the rock of fragments of the adjacent limestone and possibly of other rocks brought up from below; (4) the indication that these limestone fragments have been modified by the action of heat; (5) the fact, stated by Mr Wilkinson, that 50 feet away from the exposure, on the strike of the rocks, only gypsum was encountered." He adds: "This evidence has been developed at such length, because aside from its bearing upon Doctor Hunt's theory of the origin of serpentine, this rock is interesting as being the only known instance in the unaltered and undisturbed Paleozoic strata of New York."

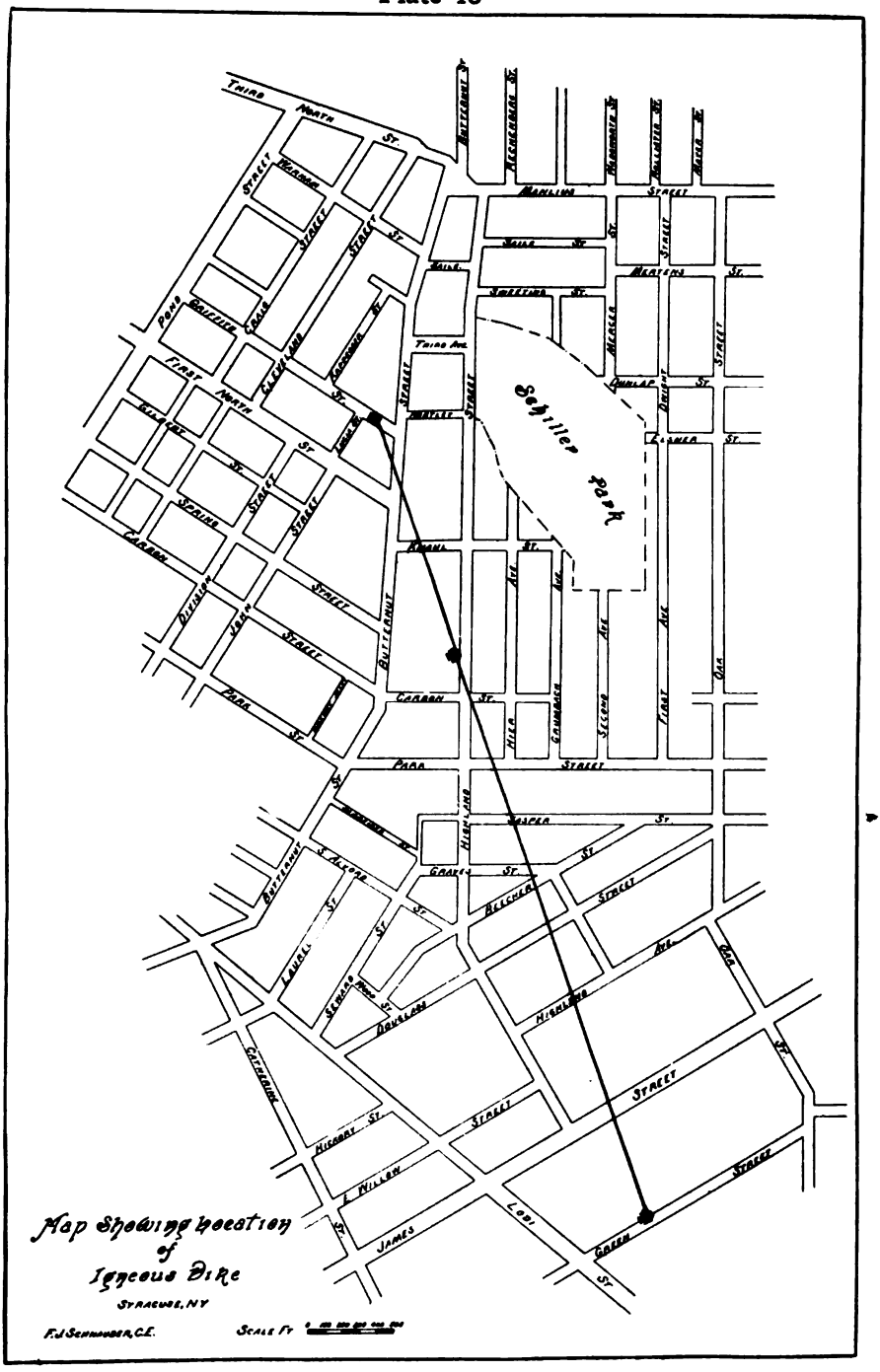
This last statement overlooked the records already published on the Manheim, Ithaca and Ludlowville dikes.

Williams compares the Syracuse peridotite with that of Elliot county, Kentucky, in which he says: "In structure, the two rocks present the closest possible similarity. The size and form of the large porphyritic olivine crystals appear to be identical in both; the ground mass of both also has the same appearance, containing in each case an abundance of opaque and transparent octahedral crystals. Nevertheless, certain mineralogical differences are apparent. The pyrope with its alteration rim, described by Mr Diller, is wanting in the Syracuse rock; ilmenite too, estimated to compose 2.2 per cent of the Kentucky peridotite, was not detected in the Syracuse occurrence. On the other hand, biotite and enstatite are much more important constituents in the latter than in the former. . . . The little transparent crystals in the Kentucky peridotite are considered by Mr Diller as anatase (octahedrite) while those in the Syracuse rock must, however, be regarded as perofskite."

Following Williams's paper were others by J. F. Kemp (35) and by P. F. Schneider (19), (24), (27), (29); D. D. Luther (21); C. H. Smyth, jr (25); and E. H. Kraus (31).

Digitized by Google

Plate 18



Digitized by Google

Digitized by Google

THE DEWITT DIKE

In 1894 P. F. Schneider discovered a new occurrence of peridotite, similar to the Green Street rock, at the Dewitt reservoir. This rock was described by N. H. Darton (35) (36) and J. F. Kemp (35). It was also described by Luther in his Report on Onondaga County (39) and an analysis of the rock was published by H. N. Stokes in Bulletin 148 of the United States Geological Survey.

DESCRIPTION OF THE SYRACUSE AND DEWITT DIKES [1]

The Syracuse dike is known to extend about seven-eighths of a mile north from Green street; how much farther is not known owing to the heavy mantle of glacial drift that covers the adjoining area. It is now exposed on Green street in the middle of the street and on the bank on the north side of the street. During the past decade it has been exposed in excavations for sewers along Highland avenue and Farmer street, some of which extending down to depths of 20 feet or more exposed the fresh unweathered rock. From these excavations the dike, or rather system of dikes, is known to extend nearly a mile; how much farther will not be known until future excavations expose it to view.

Excavations into the dike mass showed not a single dike but a complex of them in several places more or less parallel dikes varying from 5 to 35 feet thick; some of these have been traced for some distance, but the excavations were too limited to map the separate dikes. It is quite probable that these separate dikes are all united at some point or points below the surface and form parts of a single igneous intrusion that has found its way to or near the surface through a series of cracks. There seems to be no way of determining definitely whether or not these dikes poured any of their contents out over the surface of that time, nor is it possible to tell how great a thickness of rocks has been eroded from the present surface since the dike was intruded, but the bending upward of the shales in the walls of the dikes in several places would indicate, although it does not prove it, that there was not a

[1] This description is based on the papers of the writers referred to above, supplemented by my own observations. I never saw the original exposure on the "Foot Street Road" (now James street) nor that in the Dewitt reservoir, but did see the exposures in the sewer excavations along Highland avenue, Farmer and Butternut streets. T. C. H.

Digitized by Google

great thickness of rocks above the present surface. The dike rock in some places appeared to have spread out like a sill between the layers of shale. The excavations were too limited fully to establish this.

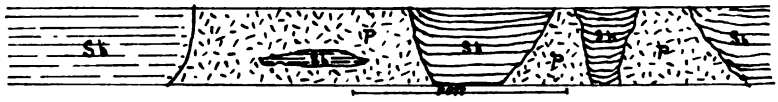


Fig. 4 Section of Green street dike along excavation made by electric light company, November 24, 1905. Sh = shale P = peridotite

Both the Green street and the Dewitt dike occur in the lower part of the Camillus shales which here contains intercalary vermicular limestone. The limestone and the shales show the effect of heat at the contact to a very limited extent, indicating that the temperature of the intrusive rock was not excessive nor the high temperature long continued, another evidence that the rocks at the present surface were not deeply buried at the time of the intrusion.

The intrusion at the Dewitt reservoir and those in the city of Syracuse at Green street, Highland avenue and Butternut street, and at Griffith street are all larger than the dikes at Manheim, Ithaca, Ludlowville and Clintonville.

Petrography. As already observed, Williams (14) was the first to prove the igneous or intrusive origin of the Syracuse dikes as previous to his examination they were considered to be metamorphosed sedimentary rocks. Smyth was the first to make a microscopic examination of the Butternut street exposure which he determined to be a porphyritic peridotite with phenocrysts of olivine. With the olivine he found some colorless pyroxene, probably augite. Biotite of a pale brown tint occurs in large irregular plates and shreds of small size; the latter appears to be secondary. Perofskite is abundant in minute crystals of sharp outline, honey-yellow and translucent. There is some magnetite and a granular mineral with a high index of refraction, which is probably a garnet. The inclusions are so numerous in some places, he says, as to equal or even exceed the dike rock in quantity. "The garnet appears rather scantily in irregular rounded grains 4 millimeters to 5 millimeters in diameter. The color is bright red." Smyth's statement regarding the size and number of the garnets was evidently based on the few specimens of rock which he had, as at the exposure there were scores of these garnets much larger than he describes.

Digitized by Google

In comparing the dike rocks, Smyth says that the Butternut street rock bears a strong family resemblance to that at Green street and at Dewitt, with perhaps less mica, and rather more perofskite, while only one section showed the tiny crystals of pyroxene that are so abundant in the Dewitt dike.

In speaking of the dikes of the county he says: "Apparently, then, the petrographic affinities of this group of dikes is with the melilite rocks rather than with the peridotites, and this is very interesting in bringing them into close relationship with the Manheim dikes, and in determining another occurrence of a rare variety of rock (alnoite)."

As might be expected, the larger Syracuse dikes contain many inclusions or fragments of the underlying rocks that were torn off from the sides of the fissure during the ascent of the molten rock. There are fragments of the inclosing and immediately underlying sedimentary shales, limestones and sandstones as well as of the deeper underlying Precambric crystallines. Most numerous are the fragments of the inclosing Camillus shales. Mr P. F. Schneider has in his possession a piece of limestone containing Trenton fossils that was taken from the dike rock. One fragment of gneiss was taken from the Green street dike that measured 8 by 14 inches, one of the largest inclusions.

Neither the inclusions or the wall rock show much metamorphism. The limestone and the shale fragments have a very thin crust, a mere fraction of an inch, that is baked by the heat of the dike.

The age of the dikes remains unknown. The Syracuse and Dewitt dikes penetrate the Camillus shales, the Ithaca and Ludlowville ones penetrate the Upper Devonic. It is probable that they are of the same age. There have been two great disturbances of the Paleozoic rocks of the eastern states: one at the close of the Ordovicic, the Taconic revolution, and one at the close of the Carbonic, the Appalachian revolution. If the Syracuse intrusions are of the same age as the others, the intrusion could not have been during the Taconic disturbance. While it is possible that the intrusions might have taken place during the Appalachian disturbance, there is no evidence to prove that they might not have occurred at a still more recent date, as during the Mesozoic period when the great trap intrusions took place along the Appalachian area. The absence of any glacial materials in the dike rock would indicate that the intrusion took place before the glacial period.

Digitized by Google

CLINTONVILLE DIKES

In the summer of 1909 Dr Burnett Smith discovered two small dikes near Clintonville, about 15 miles southwest of Syracuse. These dikes occur at the surface in rocks intermediate in age between those at Syracuse and the ones at Ithaca. Doctor Smith describes these dikes (46) as follows: "The dikes in question are exposed on the south wall of the Clintonville ravine at a point approximately 50 feet above the level of the Marietta road. The more western is a fine-grained porphyritic rock resembling peridotite. What appear to be serpentine grains, produced by the alteration of olivine, protrude from the weathered surface and have the appearance of small pebbles. Another conspicuous feature is furnished by large scales of bronzy mica. This dike has a uniform width of from 7 to 8 inches and is displayed for about 12 feet on the south bank of the ravine. On the north side it is obscured by talus. Its plane is verti-

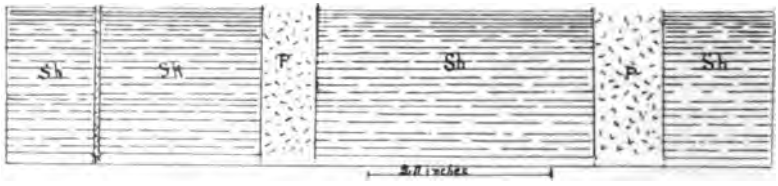


Fig. 5 Vertical section of Clintonville dikes, March 23, 1910
Sh = shale P = peridotite dike

cal while its direction is north and south, agreeing in the latter respect with the Ithaca dikes. Wherever examined it presents a very uniform texture, is apparently free from fragments of the sedimentary rocks through which it passed, and has produced little contact metamorphism.

"The second dike lies about 2 feet and 4 inches to the east of the first and was not observed until the wall at this point had been cleaned. It has a width of about 8 inches. Like the first dike, it is vertical and north and south in direction. It differs, however, from the first dike in being much weathered in places and in containing many shale fragments, some of which have a long diameter of 3 inches or more."

In a visit to this dike in the summer of 1910 I found in the shale 18 inches east of the two dikes another small dike or stringer parallel to the other two and, like them, following joint planes of the shale. It was less than an eighth of an inch in thickness, which would indicate an extreme fluidity of the dike material, as it was exposed for several feet on the wall of the ravine and continued parallel with the other dikes below the outcrop.

Digitized by Google

BIBLIOGRAPHY

Syracuse dike

(1) 1839 **Vanuxem, Lardner.** Geological Survey of New York. 3d An. Rep't of the Geol. Surv. of the 3d Dist., p. 160, 283.

(2) 1842 ———— Natural History of New York. Geol. of the 3d Dist. (Final Report), p. 109–10.

(3) 1842 **Beck, Lewis C.** Natural History of New York, pt 3, Mineralogy, p. 275.

(4) 1858 **Hunt, T. Sterry.** Contribution to the History of Ophiolites, pt 2. Am. Jour. Sci. (2) 26:234–40.

(5) 1860 **Geddes, George.** Survey of Onondaga, chapter 11, Geology. N. Y. State Agric. Soc., 19:247. 1859.

(6) 1875 **Dana, James D.** Manual of Geology. 2d ed., p. 233.

(7) 1880 ———— Manual of Geology. 3d ed., p. 233.

(8) 1886 **Hunt, T. Sterry.** Mineral Physiology and Physiography, p. 443–47.

(9) 1887 **Williams, George H.** On the Serpentine of Syracuse, N. Y. Science, 9:232–33.

(10) 1887 ———— On the Serpentine (Peridotite) occurring in the Onondaga Salt Group at Syracuse, N. Y. Am. Jour. Sci., (3) 34:137–45.

(11) 1887 ———— Perowskit in Serpentine (Peridotite) von Syracuse, N. Y. Neues Jahrbuch für Min. Geol. und Pal., 2:263.

(12) 1889 **Branner, J. C. & Brackett, R. N.** The Peridotite of Pike County, Arkansas. Am. Jour. Sci., (3) 38:50–59.

(13) 1890 ———— 11th An. Rep't Geol. Surv. of Ark., p. 377–91.

(14) 1890 **Williams, George H.** Notes on the Eruptive Origin of the Syracuse Serpentine. Geol. Soc. Am. Bul. 1, p. 533–34.

(15) 1891 **Kemp, J. F.** Peridotite Dikes in the Portage Sandstones near Ithaca, N. Y. Am. Jour. Sci., (3) 42:410–12.

(16) 1892 ———— Petrographic Notes. Trans. N. Y. Acad. Sci., XI, no. 6, p. 126–27.

(17) 1892 **Smyth, C. H., jr.** A Third Occurrence of Peridotite in Central New York. Am. Jour. Sci., (3) 43:322.

Digitized by Google

(18) 1892 **Diller, J. S.** Mica-peridotite from Kentucky. Am. Jour. Sci., (3) 44:286–89.
(19) 1894 **Schneider, Philip F.** Notes on the Geology of Onondaga County, New York, p. 17.
(20) 1896 **Kemp, J. F.** Handbook of Rocks, p. 52–53 and 113.
(21) 1898 **Luther, D. Dana.** The Economic Geology of Onondaga County, N. Y. 49th An. Rep't N. Y. State Mus., 2:16, 241–300. 1895.
(22) 1898 U. S. G. S. Bul. 150, p. 291.
(23) 1899 **Clarke, John M.** The Peridotite Dike on Green Street Hill. N. Y. State Mus. Handbook 15, p. 81.
(24) 1902 **Schneider, Philip F.** New Exposures of Eruptive Dikes in Syracuse, N. Y.
(25) 1902 **Smyth, C. H., jr.** Petrography of Recently Discovered Dikes in Syracuse, N. Y. Am. Jour. Sci., (4) 14:26–30.
(26) 1903 **Pattee, E. N.** The Analysis of the Green Street Dike. Proc. Onondaga Acad. Sci., 1, p. 3.
(27) 1903 **Schneider, P. F.** The Geology of the Green Street Dikes. Proc. Onondaga Acad. Sci., 1, p. 4.
(28) 1903 ———— The Geology of the Serpentines of Central New York. Ibid, p. 110–17.
(29) 1903 ———— Notes on Some Eruptive Dikes near Ithaca, N. Y. Ibid, p. 136.
(30) 1903 **Whitlock, H. P.** List of New York Mineral Localities. N. Y. State Mus. Bul. 70. Mineralogy 3.
(31) 1904 **Kraus, E. H.** A New Exposure of Serpentine at Syracuse, N. Y. Am. Geol., May, p. 330.
(32) 1907 **Kemp, J. F. & Ross, J. D.** A Peridotite Dike in the Coal Measures of Southwestern Pennsylvania. Annals N. Y. Acad. Sci., v. 17, no. 4, pt II, p. 509–10.

Dewitt dike

(35) 1895 **Darton, N. H.** Geologic Notes. **Kemp, J. F.** Petrographic Description. A Newly Discovered Dike at Dewitt, N. Y. Am. Jour. Sci., 49:456–62.
(36) 1895 ———— Geol. Soc. Am. Bul. 6, p. 477.
(37) 1896 **Kemp, J. F.** Handbook of Rocks, p. 49, 52–53.
(38) 1897 U. S. G. S. Bul. 148, p. 79.
(39) 1898 **Luther, D. Dana.** 49th An. Rep't N. Y. State Mus., v. 2, p. 16 and 241–300. 1895.

Digitized by Google

(40) 1902 **Schneider, P. F.** Am. Jour. Sci., (4) 14:24–25.
(41) 1902 **Smyth, C. H., jr.** Am. Jour. Sci., (4) 14:26–30.
(42) 1903 **Schneider, P. F.** Proc. Onondaga Acad. Sci., 1, p. 110–11 and 136.
(43) 1904 U. S. G. S. Bul. 228, p. 46.
(45) 1907 **Kemp, J. F. & Ross, J. G.** Annals N. Y. Acad. Sci., v. 17, no. 4, pt II, p. 509–10.
(46) 1909 **Smith, Burnett.** Dikes in the Hamilton Shale near Clintonville, N. Y. Science, 30:724.

Manheim dikes

1837 **Conrad, T. A.** 1st An. Rep't Geol. Surv. 3d Dist. N. Y., p. 161–62.
1837 **Vanuxem, Lardner.** 2d An. Rep't Geol. Surv. 3d Dist. N. Y., p. 256.
1842 ———— Natural History of New York. Geol. 3d Dist., p. 204 and 207–8.
1892 **Smyth, C. H., jr.** Am. Jour. Sci., (3) 43:322 and 46:104.
1894 **Hall, James & Darton, N. H.** 13th An. Rep't N. Y. State Geol., v. 1, Geology, p. 409–29.
1895 **Darton, N. H.** 14th An. Rep't N. Y. State Geol., p. 5–53.
1896 **Smyth, C. H., jr.** Am. Jour. Sci., (4) 2:290–92.
1898 ———— Geol. Soc. Am. Bul. 9, p. 257–68.
1899 **Clarke, J. M.** N. Y. State Mus. Handbook 15, p. 43 and 60–63.
1903 **Schneider, P. F.** Proc. Onondaga Acad. Sci. 1, p. 136.
1905 ———— Science, 22:673.
1905 **Cushing, H. P.** N. Y. State Mus. Bul. 77, p. 12.
1907 **Kemp, J. F. & Ross, J. G.** Annals N. Y. Acad. Sci., v. 17, pt II, p. 510.

Ithaca dikes

1839 **Vanuxem, Lardner.** 3d An. Rep't Geol. Surv. Third Dist., p. 260.
1842 ———— Natural History of New York, Third Dist., p. 169.
1891 **Kemp, J. F.** Am. Jour. Sci., (3) 42:410–12.

Digitized by Google

1892 **Smyth, C. H., jr.** Am. Jour. Sci., (3) 43:372.
1903 **Schneider, P. F.** Proc. Onondaga Acad. Sci., 1, p. 130–36.
1905 **Barnett, V. H.** Am. Jour. Sci., (4) 19:210.
1905 **Matson, G. C.** Jour. of Geol., p. 264–75.
1907 **Kemp, J. F., & Ross, J. G.** Annals N. Y. Acad. Sci., v. 17, pt II, p. 510.

Digitized by Google

NOTES ON THE FOSSILS OF THE PALEOZOIC FORMATIONS WITHIN THE SYRACUSE QUADRANGLE

BY BURNETT SMITH

From the standpoint of the collector, the local Paleozoic formations fall naturally into three classes — the readily accessible and highly fossiliferous Devonic and late Siluric strata, the accessible though nearly barren beds of Midsiluric age, and the drift-covered but sometimes prolific rocks of the earlier Siluric. The first group is finely displayed in the hills southeast and southwest of the city of Syracuse, that is, in the southern portion of the quadrangle. The second group of almost unfossiliferous strata is well exposed in and about the city itself and in a belt which passes across the quadrangle both east and west of the city. The rocks of the third group occupy the low drift-mantled area which lies north of Syracuse and extends to the northern limits of the quadrangle. Throughout this last area the Paleozoic strata are rarely exposed by the erosive processes and we are therefore almost wholly dependent upon excavations for such meager knowledge as we possess.

FOSSILS FROM THE NIAGARAN FORMATIONS

At one locality on the Syracuse quadrangle and at two localities on the adjoining Baldwinsville quadrangle, excavations for the barge canal have brought to light identifiable fossils. Those from Brewerton (Syracuse quadrangle) occur in an olive shale or in concretionary limy masses in the shale and have been obtained in deepening the channel of the Oneida river. At Phoenix (Baldwinsville quadrangle) there is likewise an olive shale quite similar to that from Brewerton and here it has been possible to collect from the rock in place. The third locality, situated between Phoenix and Brewerton, has furnished a few fossils from a calcareous shale which is harder and of a more grayish tint.

At Phoenix we are apparently dealing with a homogeneous fauna from a single formational unit, but at the other two localities (more especially at Brewerton) it is highly probable that the excavations have penetrated more than one fossiliferous horizon.

The chief interest attaching to these strata is the question of their equivalency with either the Rochester shale or with some member of the Clinton group. Though the few fossils so far determined are hardly sufficient to solve this problem, it is deemed

Digitized by Google

advisable to show in tabular form their local occurrence and their distribution in the Rochester shale and Clinton group.[1]

	Brewerton	Phoenix	Two and one-half miles northeast of Three River Point	Rochester shale	Clinton group
Rusophycus bilobatus (*Vanuxem*)	X				X
Retepora angulata *Hall*		X			X
Pholidops squamiformis (*Hall*)	X			X	
Leptaena rhomboidalis *Wilckens*		X	X	X	
Plectambonites transversalis (*Dalman*)		X		X	
Atrypa reticularis *Linné*	X	X	X	X	X
Spirifer radiatus *Sowerby*		X		X	X
S. niagarensis (*Conrad*)			X	X	
Avicula emacerata *Conrad*	X	X	X	X	X
Orthonota curta *Hall*	X			?	X
Bellerophon (species undetermined)			X		
Conularia (species undetermined)	X				
Orthoceras cancellatum *Hall*		X		X	
O. annulatum *Sowerby*		X		X	?
O. (species undetermined)	X	X			
Lichas boltoni (*Bigsby*)	X			X	
Calymmene (species undetermined)	X	X			
Dalmanites limulurus (*Green*)		X		X	X
Beyrichia symmetrica (?) *Hall*	X			X	

Besides the Niagaran forms listed above, a few fossils have been obtained from a dolomite believed to be the eastern extension of the Lockport. Fragmentary brachiopod shells have been found in blocks of this material which were removed from the bed of the Oneida river at Oak Orchard. About 4 miles away at a quarry just south of Three River Point (Baldwinsville quadrangle) a similar rock, in addition to obscure fragments, carries a Leperditia-like ostracod and a Spirifer apparently of the crispus type.

THE SPARSE FAUNA OF THE SALINA BEDS

Of the lithologic units included under this heading, only one, the Camillus, has furnished fossils in the Syracuse area. The eurypterid-bearing Pittsford shale, which constitutes the base of the group in western New York, has here remained unrecognized while the over-

[1] For the horizons and localities of Clinton group and Rochester (Niagara) shale species, see Hall, Palaeontology of New York, v. 2. For a list of the common Rochester shale species, see Hartnagel, N. Y. State Mus. Bul. 114. p. 19.

Digitized by Google

lying red Vernon shale is unfossiliferous. In the succeeding Camillus formation gypseous shales and the casts of halite crystals indicate a body of water cut off from the sea and rendered so saline by excessive evaporation that life within its confines was all but impossible.

In a limestone (Fiddler's Green) lying near the top of the Camillus series, a poorly preserved Leperditia is encountered in great numbers. This horizon is both overlaid and underlaid by gypsum beds and points to a slight freshening of the water which permitted this hardy form to swarm into the area.

Above the gypseous shales and limestones of the Camillus comes the Bertie waterlime, regarded as the final stage of the Salina group. Though noted in western New York and in Herkimer county for its beautifully preserved eurypterids, the Bertie is here lacking in organic remains.

The entire Salina group of strata, beginning with the Pittsford and ending with the Bertie, represents a nonmarine series. During its deposition any communication with the sea was, at best, inadequate and transitory and was never sufficient to allow the invasion of a marine fauna.

THE FAUNAS OF THE UPPER CAYUGAN GROUP

This group of strata is ordinarily made to comprise the Cobleskill dolomite, Rondout dolomite and Manlius limestone.

Cobleskill dolomite. In central New York this oldest member of the group is difficult of discrimination on a paleontologic basis. As a rule the rock is unfossiliferous, but Hartnagel[1] has reported Spirifer crispus var. corallinensis Grabau, Whitfieldella nucleolata Hall, Chonetes jerseyensis Weller and Stropheodonta bipartita Hall from the town of Dewitt. The rich and decidedly late Siluric fauna listed by the same author[2] from Schoharie county has not been detected in the local outcrops.

Rondout dolomite. The Rondout is a very sparingly fossiliferous formation, generally regarded as representing a partial return to Salinalike conditions. Eurypterids occur at this horizon near Union Springs, Cayuga county, and at Seneca Falls,[3] but in the Syracuse area the only fossil so far observed is a small Spirifer apparently identical with S. vanuxemi Hall. This species,

[1] N. Y. State Mus. Bul. 69, p. 1161.
[2] *Ibid*, p. 1126–28.
[3] N. Y. State Mus. Bul. 69, p. 1157.

Digitized by Google

Cyathophyllum hydraulicum Simpson and Leperditia alta are reported by Clarke and Luther[1] from the Rondout of the Tully quadrangle immediately south of Syracuse.

Manlius limestone. The Manlius limestone or uppermost member of the group carries a marine fauna which is remarkable for the abundance of its individuals and the fewness of its species. Crinoids, a Stromatopora and the brachiopods Spirifer vanuxemi Hall and Strophеodonta varistriata (Conrad) are mingled with other, possibly pelagic, forms such as Tentaculites gyracanthus Eaton, Leperditia alta (Conrad) and a species of Beyrichia.

This assemblage has been regarded as a "dwarf" fauna by Shimer[2] who says, "The occurrence of these dwarf faunas between the periods of small exceedingly dense seas or lakes, depositing salt and gypsum, and the normal marine conditions of the Helderbergian is an additional proof of the greater-than-normal density of the water at that time." The mud-crack zones of the Manlius clearly indicate that the material accumulated at no great depth and it is not unlikely that the environment of a shallow fluctuating sea may account, in part at least, for the peculiarly restricted life. Whatever the explanation, it is obvious that the physical conditions were unfavorable for the growth and development of a rich and diversified marine fauna.

The intercalations of drab waterlime which occur near the top of the Manlius and which make so striking a color contrast with the blue limestone, are generally believed to indicate a return of the conditions which prevailed during Rondout and Salina time. This view is strongly supported by Mr Luther's find of eurypterids in the Manlius waterlime of Split Rock.[3]

REPRESENTATIVES OF THE HELDERBERGIAN FAUNAS

In most sections of the limestone escarpment south of Syracuse there intervene between the terminal waterlime bed of the Manlius and the Devonic Oriskany sandstone, a varying number of feet of limestone which carry a mixture of indigenous forms persisting from the Manlius, and of exotic types strongly suggestive of the Helderbergian faunas, which attain their highest expression in the eastern portion of the State. These invaders are, however, apparently

[1] N. Y. State Mus. Bul. 82, p. 38.
[2] American Naturalist, 42:481.
[3] N. Y. State Mus. Bul. 69, p. 1163.

Digitized by Google

always inferior in number of individuals to the forms of Manlius origin. The massive beds of Stromatopora are the conspicuous feature of the strata, while the Helderbergian brachiopods, gastropods, crinoids and corals are observed only after a closer inspection of the rock.

At Manlius, just beyond the eastern boundary of the quadrangle, the Helderbergian element is more pronounced, but even here it is not uncommon to find a Helderbergian Favosites completely overgrown and overwhelmed by the native Stromatopora. The percentage of Helderbergian forms seems to increase on going eastward in the Syracuse quadrangle, but all the evidence points to the conclusion that though they invaded the area these immigrants were unable thoroughly to accommodate themselves to the environment which had been so suitable to the peculiar life of the Manlius waters.

Near the village of Manlius, Hartnagel[1] has collected the following representatives of the Helderbergian faunas:

Leptaena rhomboidalis *Wilckens*
Orbiculoidea cf. discus *Hall*
Spirifer cyclopterus *Hall*
Strophcodonta becki *Hall*
Trematospira formosa *Hall*
Meristella cf. laevis *(Vanuxem)*
Conocardium sp. undet.
Pterinea communis *Hall*
Tentaculites elongatus *Hall*
Leperditia sp. undet.

FOSSILS OF THE ORISKANY SANDSTONE

The Oriskany lies, throughout the quadrangle, with a slight unconformity on all older formations. It is a deposit formed in a transgressing sea, not far from land, and in comparatively shallow water. As might be expected, the sand often contains fragments of preexisting formations and not infrequently fossils derived from these formations. It likewise carries marine fossils which undoubtedly represent the remains of animals which actually *lived* in the Oriskany sea. Phosphatic nodules scattered through the formation may possibly be assignable to a coprolitic origin. They occasionally include bone fragments and spines (Machaeracanthus)— the oldest fish remains in the quadrangle.

The most abundant Oriskany invertebrates are the brachiopods Spirifer arenosus (Conrad), Spirifer arrectus

[1] N. Y. State Mus. Bul. 69. p. 1164.

Digitized by Google

Hall, Hipparionyx proximus Vanuxem, Rensselaeria ovoides (Eaton) and the gastropod Platyostoma ventricosa Conrad.

As an example of a derived fossil we may cite Stromatopora, and it is not unlikely that the cosmopolitan Leptaena rhomboidalis owes its presence here to the same causes. The absence of the Helderbergian strata at certain localities in the quadrangle renders it highly probable that these two fossils were derived from beds of this age which were planed away by the advancing Oriskanian sea.

THE FAUNA OF THE ONONDAGA LIMESTONE

Lying above the thin sands of the Oriskany comes the massive Onondaga limestone. In the numerical abundance of its individuals and in its diversified nature, as well as in the beauty of many of its species, the Onondaga is the most noteworthy fauna to be found in the local Paleozoic series. At certain places and at certain horizons the rock may, it is true, be quite barren of fossils: sometimes secondary crystallization has obliterated or at least obscured the traces of life; but, on the whole, it is a highly fossiliferous formation.

At the famous collecting ground in the Split Rock quarries, the sea must have literally teemed with life. Crinoidal fragments and corals (many probably in the position of growth) are the most abundant fossils, but bryozoa, brachiopods, gastropods and trilobites are well represented.

This assemblage gives a picture of the rich life of a favorable Paleozoic marine environment, and, if one is permitted to judge it in the light of what is going on today, he is justified in assuming a warm sea of moderate depth, vigorous currents, and an abundant food supply of minute organisms.

In addition to the corals of difficult specific determination, but referable to the genera Zaphrentis, Heliophyllum and Favosites, it is practicable to list here only a few of the most common fossils of the local exposures, as:

Atrypa reticularis *Linn.*
Meristella nasuta *(Conrad)*
Dalmanella lentiformis *(Hall)*
Leptaena rhomboidalis *Wilckens*
Platyostoma turbinata *Hall*
Strophostylus varians *Hall*
Platyceras (numerous species)
Phacops cristata *Hall*
Dalmanites (Odontocephalus) selenurus *(Eaton)*

Digitized by Google

Among the rarer but highly interesting specimens which occasionally reward the collector we may mention spinelike pieces of bone apparently referable to the fish Machaeracanthus and fragments of the giant trilobite Dalmanites (Coronura) myrmecophorus (Green).

THE MARCELLUS FAUNAS

The series of about one hundred feet of strata which have been assigned to the Marcellus formation, exhibit two somewhat diverse faunal elements. These are the Black shale fauna and the fauna of the Agoniatites limestone intercalation which occurs in the lower fifteen feet of the series.

Though certain species are common to these two lithologic phases of the Marcellus, the limestone is to be distinguished by the presence of large types of cephalopods which are found at no other horizon within the quadrangle. Almost every exposure of this limestone will yield specimens of Goniatites vanuxemi Hall (=Agoniatites expansus (Van.)) and Orthoceras marcellensis Hall.

The black shales are prevailingly unfossiliferous, yet thin bands or concretionary masses may present the brachiopod Liorhynchus limitaris (Vanuxem) and the pteropod Styliolina fissurella (Hall) in countless numbers. Besides these diminutive invertebrates the shales occasionally furnish fragmentary remains of good sized fishes which can be provisionally assigned to the genera Dinichthys and Onychodus.

This peculiar association of small bottom-living invertebrates with mobile and planktonic types appears to be a normal one for black shales generally and, taken in connection with the characters of the shales themselves, has been interpreted as signifying an environment similar to that of the present Black sea.[1]

---

[1] Clarke, John M. N. Y. State Mus. Mem. 6, p. 200. 1903. Schuchert, Charles. Geol. Soc. Am. Bul. 20, p. 446. 1910.

Digitized by Google

A REVIEW OF THE MAMMALIAN REMAINS FROM THE SUPERFICIAL DEPOSITS IN THE VICINITY OF ONONDAGA LAKE, NEW YORK

BY BURNETT SMITH

Onondaga lake presents along its margins and in its low-lying tributary valleys, a series of clay, marl and peat deposits which are clearly of later date than the latest glaciation of the region. It can not be stated, at present, whether they were laid down in connection with a once larger and higher lake or in and about separate but more or less contemporaneous water bodies which were left behind in the shrinking of such a lake. The highest altitude at which materials of this series have been observed is slightly over 400 feet, that is, approximately 35 or 40 feet above Onondaga lake. They therefore lie below the youngest glacial water level and though their oldest portions may go back to the time immediately following the abandonment of the Mohawk glacial drainage outlet at Rome[1] (now about 460 feet in altitude), their youngest layers fall within historic time and are even accumulating in connection with Onondaga lake today.

On account of the almost complete absence of natural exposures one is obliged to depend upon excavations for a knowledge of the structure and stratigraphy. From the same cause the few mammalian fossils from this series have been obtained at irregular intervals and from scattered localities. The specimens which are available for study have been deposited at Syracuse University by different collectors through a period of about thirty years and comprise the remains of black bear, Virginia deer, American bison and an elephant referable to the northern mammoth.

In the cases of some of the specimens a few measurements have been published but little attention has been paid to their geological environment. In any attempt at correlation ordinary stratigraphic methods can not, it is true, be employed; but for that very reason all obtainable information concerning exact locality and horizon becomes of greater value. Also on account of the fact that some of the specimens are liable to the vicissitudes of privately owned material, it is believed that photographic reproductions of the more important finds should be published.

---

[1] H. L. Fairchild. Glacial Waters in Central New York. N. Y. State Mus. Bul. 127, p. 55, 59.

The present divide is below 440 feet (see U. S. G. S. topographic sheets of the Oriskany and Chittenango quadrangles).

Digitized by Google

Ursus americanus Pallas

Black bear

Plate 1

Locality. Will and Baumer factory, north side of Ley creek on the east shore of Onondaga lake, New York (see U. S. G. S. topographic sheet of the Syracuse quadrangle).

These remains were briefly described by Smallwood[1] in 1903. They comprise two skulls, three mandibles, two left mandibular rami, three left humeri, two right humeri, one left tibia, one right tibia, and one right fibula.

The smaller skull is, on the whole, not so well preserved as the larger skull. Many measurements which were made in the larger were not attempted in the case of the smaller skull.

This collection of bones indicates five or more individuals. Comparisons with recent specimens of the black bear from New York and Pennsylvania disclose no differences which can be regarded as specific. Professor Smallwood in his original description suggests that we are dealing with animals which were killed by man. Certain holes in the larger skull do have more or less resemblance to those made by bullets but while admitting freely (as one must admit in dealing with any Quaternary fossil) that man may have been the cause of death, the author considers that these remains exhibit no indubitable evidence of such a cause. Mr Edward Baumer of Syracuse states that all the bones were secured during excavations which reached from the surface through the peaty layers into marl below. The specimens were found immediately above the marl at a depth of about 10 feet. Even allowing for the sinking of heavy carcasses through soft material, one is justified in assuming a considerable antiquity for remains found in such deposits at that depth. Though the inclosing material was accumulated not far from a still extant water body which is subject to considerable fluctuation in level, the author feels at liberty to express the opinion that these specimens are older and perhaps very much older than the white settlement of the region.

Odocoileus americanus (Erxleben)

Virginia deer or White-tailed deer

Locality. Will and Baumer factory, north side of Ley creek on the east shore of Onondaga lake, New York (see U. S. G. S. topographic sheet of the Syracuse quadrangle).

[1] **W. M. Smallwood. The Remains of Bear and Deer on the Shores of Onondaga Lake.** Science, n.s., v. 18, no. 444, p. 26, 27. July 3, 1903.

Digitized by Google

These remains were briefly described by Smallwood[1] in 1903. They comprise two large humeri each accompanied by its corresponding radius and ulna, two small humeri, one metacarpus, six ribs, one lumbar vertebra, one thoracic vertebra and one atlas.

The two larger humeri lack the proximal epiphyses and have such similar proportions, state of preservation and color that it is scarcely probable that they belonged to two different individuals. Each articulates perfectly with a corresponding radius and ulna.

The two smaller humeri, like the larger specimens, lack the proximal epiphyses. The longer and more slender of these bones (a right) measures in its fragmentary condition, 157 mm in length and 34 mm transversely across the anterior face of the trochlea. Similar measurements on the shorter and more robust humerus (a left) are 145 mm and 35 mm respectively.

The metacarpus (a left) presents the following measurements: length 226 mm, transverse diameter of the inferior epiphysis 32 mm, transverse diameter of the proximal articular surface 28 mm.

The collection of bones from this locality indicates the remains of three or more individuals. Comparisons with recent specimens of the Virginia deer disclose no differences which can be regarded as specific. The specimens came from the same excavation, in which the bear remains (described above) were found. The larger limb bones present a much fresher appearance and better state of preservation than any of the other specimens from this locality. The two smaller humeri show adherent particles of shell fragments and were evidently collected from the marl. The other bones, with one exception,[2] are apparently from the peaty layers above the marl or from the contact of the two deposits. The superior preservation of the larger deer bones may, in the absence of contrary evidence, be urged as an argument in favor of their recent introduction by sinking through soft material. Condition of preservation is, however, an uncertain guide to age and it is believed that in this case the association of remains points to approximate contemporaneity for the different individuals.

---

[1] W. M. Smallwood. The Remains of Bear and Deer on the Shores of Onondaga Lake. Science, n.s., v. 18, no. 444, p. 26, 27. July 3, 1903.

[2] The antler fragment mentioned by Professor Smallwood was supposed to have been collected with the other deer remains. Adherent grains of quartz sand indicate, however, that the specimen came from a different level or more probably from a different locality. It has clearly been cut or sawed but the artificial surfaces, though weathered, show no adherent particles of quartz sand or other material.

Digitized by Google

Locality. Harbor brook near Avery avenue (city line on west), Syracuse, New York (see U. S. G. S. topographic sheet of the Syracuse quadrangle in the valley south and east of "Burnett Park").

During the summer and autumn of 1912 a sewer excavation in the Harbor Brook valley cut down through the swamp deposits to a depth of from 10 to 15 feet. The layers of different materials exhibited a variable and irregular structure but in general the normal sequence of such deposits could be observed. That is, a bluish clay occurred below, followed by marly bands which in turn were overlaid by peaty layers. Locally where the trench crossed Avery avenue a firm calcareous tufa capped the peat.

From the material thrown out of this excavation the writer has obtained one left metacarpus, one right metacarpus and several antler fragments which are all referable to the Virginia deer. On account of their color and adherent particles of marl, it is probably safe to say that the specimens came from below the superficial layer of peat.

The locality is about 2 miles from the present Onondaga lake and its altitude is slightly below the 400 foot contour or about 30 feet above the lake. It is not unlikely that the deposits formed at this point were laid down in and about an arm of a once greater Onondaga lake. If this view is correct, the Harbor brook specimens are much older than those from Ley creek. If, on the other hand, the materials owe their origin to a remnant contemporary pond, it is hardly possible to arrive at any conclusion on the relative ages of the two finds.

Bison bison (Linn.)

American bison

Plate 2

Locality. North side of Croton street (now East Raynor avenue) and 210 feet west of Renwick avenue, Syracuse, New York (see U. S. G. S. topographic sheet of the Syracuse quadrangle near the bend in the 400 foot contour line just above the northern boundary of "Oakwood cemetery").

This skull was briefly described by Underwood[1] in 1890. The teeth are either lost or broken away but the nasals, premaxillaries and horns are preserved.

[1] Lucien M. Underwood. A Bison at Syracuse, New York. The American Naturalist, 24:953. October 1890.

Digitized by Google

Comparisons of the photographs of this specimen with the skulls of recent individuals of the American bison fail to reveal any differences which can be regarded as specific. Underwood in his original description states: "The formation was of black swamp muck underlaid by clay; the skull being found at the junction of the two deposits." Its depth below the surface is stated to have been "about 10 feet."

Mr John Cunningham of Syracuse, the owner of the specimen, places the depth at 17 feet and the position as below the "muck." The unstained condition of the skull and the presence of shell fragments between the horns and the horn cores strongly support this latter statement.

In spite of these very natural discrepancies of a few feet in the observation of its geological horizon, this specimen can be regarded as unquestionably of considerable age. If the stratum in which it occurred was laid down in a greater Onondaga lake, then the Syracuse bison is much older than the bear and deer remains from Ley creek. Until, however, more is known of the stratigraphy of these layers this conclusion must remain unverified. The altitude of this locality is about 400 feet, or approximately 36 feet above Onondaga lake.

Elephas primigenius Blumenbach

Northern mammoth

Locality. East side of Limestone creek near Manlius Station (now Minoa) on the West Shore Railroad (see U. S. G. S. topographic sheets of the Syracuse and Chittenango quadrangles).

The specimens assignable to Elephas primigenius were unearthed during the construction of the West Shore Railroad and probably in the year 1883. They comprise one cheek tooth and portions of a tusk or tusks. The best preserved tusk fragment and the molar were secured for Syracuse University through the enterprise of Mr John Cunningham.

The molar is of interest on account of its approach to that of the southern mammoth (Elephas columbi Falconer). In the number and character of its enamel ridges it undoubtedly presents some resemblance to the teeth of E. columbi but it is nevertheless probably referable to the northern form.[1] The tusk

[1] Dr O. P. Hay and Dr W. K. Gregory have both examined photographs of this specimen and have very generously given the author the benefit of their opinions on its specific position.

Digitized by Google

possesses a diameter of about 180 mm near the base, while the molar which is from the left side of the lower jaw, measures 250 mm on a grinding surface which is incomplete through breakage.

The specimens indicate a large individual and it is indeed unfortunate that we have only meager records of its horizon and of the material in which it was found. Mr Cunningham has assured the writer that the position of these remains was quite superficial. An inspection of the locality leads to the belief that the specimens could not have been unearthed much, if at all, above the 400 foot contour. A few fragments of vegetable matter are still adherent on the tusk but the unstained condition of all the specimens makes it unlikely that true peat was the inclosing deposit.

Both tusk and molar are now in a very friable condition but this, by itself, can hardly be advanced as a certain sign of great antiquity. We are dealing with an extinct animal, it is true, yet no evidence has so far appeared to prove indubitably its reference to any system of deposits differing materially in age from those which included the other mammalian remains considered in this paper.

HISTORICAL EVIDENCE OF THE ABUNDANCE OF MAMMALS IN THE VICINITY OF ONONDAGA LAKE

The superficial deposits in the vicinity of Onondaga lake are now yielding and have in the historic past always furnished many saline springs. For this reason the abundance a century ago of the mammals which still exist in the more unsettled portions of the State is in no way surprising. The presence in large numbers of the American bison or buffalo at about the same date is, however, not generally admitted. The occurrence of a fossil specimen at Syracuse and of the bear and deer remains near Onondaga lake throws an interesting light upon the following curious account published by Thomas Ashe[1] in 1808:

The native animals of the country too, as the buffalo, elk, deer etc. are well known to pay periodical visits to the saline springs and lakes, bathing and washing in them, and drinking the water till they are hardly able to remove from their vicinity. The best roads to the Onondargo from all parts, are the buffalo tracks; so called from having been observed to be made by the buffaloes in their annual visitations to the lake from their pasture grounds; and though this is a distance of above two hundred miles, the best

[1] Travels in America, Performed in 1806, etc. London 1808. p. 47.

Digitized by Google

surveyor could not have chosen a more direct course, or firmer or better ground. I have often travelled these tracks with safety and admiration. I perceived them chosen as if by the nicest judgment; and when at times I was perplexed to find them revert on themselves nearly in parallel lines, I soon found it occasioned by swamps, ponds, or precipices, which the animals knew how to avoid: but that object being effected, the road again swept into its due course, and bore towards its destination as if under the direction of a compass.

An old man, one of the first settlers in this country, built his log house on the immediate borders of a salt spring. He informed me that for the first several seasons, the buffaloes paid him their visits with the utmost regularity; they travelled in single files, always following each other at equal distances; forming droves, on their arrival, of about three hundred each. The first and second years, so unacquainted were these poor brutes with the use of this man's house or with his nature, that in a few hours they *rubbed* the house completely down; taking delight in turning the logs off with their horns, while he had some difficulty to escape from being trampled under their feet, or crushed to death in his own ruins. At that period he supposed there could not have been less than ten thousand in the neighborhood of the spring. They sought for no manner of food; but only bathed and drank three or four times a day, and rolled in the earth; or reposed, with their flanks distended, in the adjacent shades; and on the fifth and sixth days separated into distinct droves, bathed, drank, and departed in single files, according to the exact order of their arrival. They all rolled successively in the same hole; and each thus carried away a coat of mud, to preserve the moisture on their skin; and which, when hardened and baked by the sun, would resist the stings of millions of insects that otherwise would persecute these peaceful travellers to madness or even death.

In the first and second years this old man with some companions killed from six to seven hundred of these noble creatures, merely for the sake of the skins, which to them were worth only two shillings each; and after this "work of death," they were obliged to leave the place till the following season; or till the wolves, bears, panthers, eagles, rooks, ravens etc. had devoured the carcasses, and abandoned the place for other prey. In the two following years, the same persons killed great numbers out of the first droves that arrived, skinned them, and left the bodies exposed to the sun and air; but they soon had reason to repent of this; for the remaining droves, as they came up in succession, stopped, gazed on the mangled and putrid bodies, sorrowfully moaned or furiously lowed aloud, and returned instantly to the wilderness in an unusual run, without tasting their favorite spring, or licking the impregnated earth, which was also once their most agreeable occupation; nor did they, or any of their race, ever revisit the neighborhood.

The simple history of this spring, is that of every other in the

Digitized by Google

settled parts of the western world; the carnage of beasts was everywhere the same. I met with a man who had killed two thousand buffaloes with his own hand; and others, no doubt, have done the same. In consequence of such proceedings, not one buffalo is at this time to be found east of the Mississippi; except a few domesticated by the curious, or carried through the country as a public shew. . . .

The salt lakes and springs are also frequented by all the other kinds of beasts, and even by birds; and from the most minute inquiries, I am justified in asserting that their visitations were periodical; except doves, which appear to delight in the neighborhood of impregnated springs, and to make them their constant abode. In such situations they are seen in immense numbers, as tame as domestic pigeons, but rendered more interesting by their solitary notes and plaintive melody.

CORRELATION AND SUMMARY

It has already been pointed out that ordinary stratigraphic methods can not be employed with the series of deposits whose mammalian remains have formed the subject of this paper. The series lies stratigraphically above glacial deposits, but beyond that, our most valuable criterion — geological superposition — fails us. It is therefore necessary to fall back upon geographic methods, correlating by contours and their relation to existing water bodies.

The highest altitude at which excavations in these deposits have yielded fossils is a little over 400 feet. This lies well below the present altitude of the Mohawk glacial drainage outlet at Rome. This outlet is believed to have been that of an ice-dammed lake whose level was controlled by a glacial lobe in the St Lawrence valley and which is generally regarded as the last of the succession of water surfaces to be maintained by the retreating margin of the Labradorian ice sheet.[1]

The deposits inclosing the mammalian remains under discussion lie therefore below the last ice-controlled water level and were consequently laid down in and about water bodies which were in no way affected, even remotely, by a glacial dam. On this account these accumulations must be regarded as strictly postglacial. It should also be noted in this connection that the layers yielding fossils are superficial, being, as far as ascertained, less than 20 feet below the present land surface.

Onondaga and Oneida, as well as several other lakes in the lowlands of central New York, probably represent all that is left of

[1] See N. Y. State Mus. Bul. 127, pl. 42, page 10.

Digitized by Google

a once greater postglacial lake. If the deposits under consideration were laid down in connection with one uniformly shrinking and lowering water body, it is reasonable to assume that (depth below the present land surface being constant) those remains which are found far from existing lakes are older than the remains occurring in close proximity to the present lakes. On the other hand if the deposits represent those of separate and more or less contemporary ponds, no statement can be made except that they are all postglacial in age.

Though a final conclusion upon this particular phase of the problem must await future investigation, the writer feels at liberty to express the opinion that all the remains here considered are those of animals which lived at a time or at different times approaching the present much more closely than the date of the last glacial water level. The strongest evidence in support of this view is the superficial position of all the specimens.

A careful survey of the associated molluscan and plant life has not yet been made, but no facts have so far appeared to warrant the belief that the series of deposits under discussion contain more than one biological association. If we accept the classification of Osborn[1] we are apparently dealing with his Fourth Quaternary, *Cervus*, or Holocene fauna. With the exception of *Elephas*, all the forms here considered are those of which we have historic records for America. In the individual case of the Manlius Station (or Minoa) elephant it might be stated that the author has, so far, failed to obtain the slightest evidence which might justify its reference to any system of deposits materially older than those which furnished the bear, deer and bison remains described in this paper.

Acknowledgments. In the preparation of these notes comparisons were made with material belonging to the United States Biological Survey, the United States National Museum, the American Museum of Natural History, and the Academy of Natural Sciences of Philadelphia. To the officers of these institutions, to Dr O. P. Hay of the Carnegie Institution, to Prof. Amos P. Brown of the University of Pennsylvania, to Professors W. M. Smallwood and T. C. Hopkins of Syracuse University, to Messrs John Cunningham, Philip F. Schneider and Edward Baumer of Syracuse, to Mr DeCost Smith of New York City, and to Mrs Ethel Ostrander Smith, the author wishes to express his thanks. .

[1] H. F. Osborn. The Age of Mammals, p. 372, 440.

Digitized by Google

EXPLANATIONS OF PLATES

Plate I

73

Digitized by Google

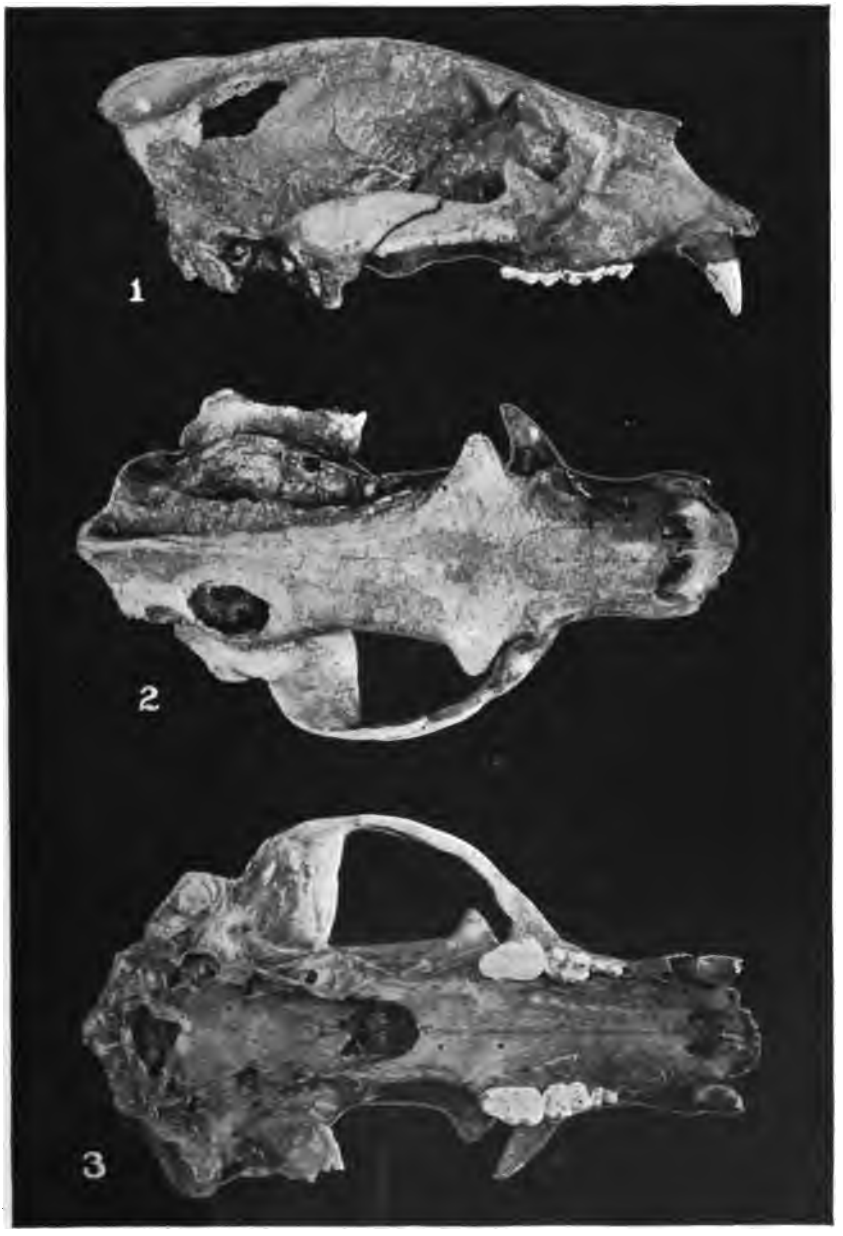
Ursus americanus Pallas

Page 65

Fig. 1 Skull, lateral aspect.
2 Skull, superior aspect.
3 Skull, inferior aspect.
Locality: Quaternary, Ley creek, Onondaga lake, N. Y.

Digitized by Google

Plate 1



Digitized by Google

Digitized by Google

Plate 2

75

Digitized by Google

Bison bison (Linn.)

Page 67

Fig. 1 Skull, superior aspect.
2 Same, with horns removed from horn cores.
3 Skull, posterior aspect.
4 Same as figure 3, with horns removed from horn cores.
5 Skull, lateral aspect.
6 Same as figure 5, with horns removed from horn cores.
Locality: Quaternary, Syracuse, N. Y.

Digitized by Google

Plate 2

Digitized by Google

Digitized by Google

INDEX

Agoniatites expansus, 25, 63
Agoniatites limestone, 6, 25, 63
Atrypa reticularis, 58, 62
Avicula emacerata, 58
Ayres, O. L., cited, 6

Baldwinsville, 9
Baldwinsville quadrangle, 57
Baumer, Edward, acknowledgments to, 72
Bear, black, 65
Beck, Lewis C., cited, 46
Belle Isle, 11, 37
Bellerophon, 58
Bertie waterline, 6, 15, 30, 59; inferior for building stone, 26
Beyrichia, 60
symmetrica, 58
Bison, American, 67, 69
Bison bison, 67, 76
Black shale fauna, 63
Bonsteel, F. E., cited, 6
Brewerton, 7, 8, 57
Bridgeport, 10
Britton's quarry, 20
Brown, Amos P., acknowledgments to, 72
Buffaloes, 67, 69
Building stone, 26
Butternut creek, 31, 41, 43

Calymmene *sp.*, 58
Camillus limestone, inferior for building stone, 26
Camillus shale, 6, 12, 30, 31, 38, 58
Cardiff, 34
Cardiff shales, 6, 24, 25, 38
Carter, William T. jr, cited, 6
Cayugan group, 10; faunas, 59
Cement and lime, 28
Channels, 41
Cherry Valley limestone, 6, 25
Chittenango, 8
Chonetes jerseyensis, 59
lineatus, 24
Chrysler station, 13, 17
Chrysler's glen, 13
Cicero, 9
Cicero swamp, 10, 11, 35, 37
Clark, B. W., cited, 40
Clarke, J. M., cited, 17, 21, 60, 63
Clay, 34, 37
Clay station, 10
Clinton beds, 6
Clinton-Rochester shales, 7
Clintonville dikes, 2
Cobleskill, 16
Cobleskill dolomite, 6, 15, 26, 59
Coeymans ? limestone, 6
Concrete, 26
Conocardium *sp.*, 61
Conularia, 58
Corniferous limestone, 22, 27
Crushed stone, 26
Cunningham, John, acknowledgments to, 72
Cyathophyllum hydraulicum, 15, 60

Dalmanella lentiformis, 62
Dalmanites limulurus, 58
(Coronura) myrmecophorus, 63
(Odontocephalus) selenurus, 62
Dana, cited, 47
Darton, N. H., cited, 49
Deer, Virginia or white-tailed, 65
Dewitt, 11
Dewitt dike, 49; bibliography, 54
Dikes, 45
Dinichthys, 63
Dorwin springs, 44
Drumlins, 43

East Onondaga, 21
Economic geology, 26
Elephas primigenius, 68
Englehardt, cited, 8, 10
Evergreen lake, 44
Explanations of plates, 73

Digitized by Google

Fairchild, H. L., cited, 6, 42, 64
Faults, 39
Favosites, 61, 62
Fayetteville, 12, 13, 14, 19, 29, 30
Fiddler's Green, 39
Fiddler's Green limestone, 6, 12, 15, 39, 59
Fillmores Corners, 39
Finger Lakes district, 44
Fossils of the Paleozoic formations within the Syracuse quadrangle, 57

Geddes, George, cited, 47
Goniatites vanuxemi, 63
Gravel and sand, 29
Gray limestone, building stone, 26
Green lake, 21
Gregory, W. K., cited, 68
Gypsum beds, 12, 30

Hall, cited, 58
Harris, cited, 17, 20
Hartnagel, C. A., cited, 7, 8, 16, 17, 19, 20, 58, 59, 61
Hay, O. P., acknowledgments to, 72; cited, 68
Helderberg limestones, 19, 28, 29; use for building stone, 26
Helderbergian faunas, representatives of, 60
Heliophyllum, 62
Hipparionyx proximus, 62
Hopkins, T. C., acknowledgments to, 72
Hunt, T. Sterry, cited, 46, 47
Hydrology, 43

Igneous rocks, 40
Ihlseng, M. C., cited, 21
Ithaca dikes bibliography, 55

Jamesville, 17, 19, 20, 21, 29, 30

Kemp, J. F., cited, 48, 49
Kimber springs, 17, 25, 44
Kirkville, 13, 37
Kraus, E. H., cited, 14, 48

Lake deposits, 34
Lake plains, 43
Leperdita *sp.*, 61
  alta, 60
  scalaris, 13
Leptaena rhomboidalis, 58, 61, 62
Ley creek, 43
Lichas boltoni, 58
Lime, 28
Limestone creek, 31, 44
Limestone valley, 41
Liorhynchus limitaris, 63
Lockport limestone, 6, 9; inferior for building stone, 26
Lodi, 40
Luther, D. D., cited, 26, 40, 48, 49, 60
Lyndon, 12, 16, 30, 31
Lysander, 9

Macadam, 26
Mammalian remains from the superficial deposits in the vicinity of Onondaga lake, 64
Mammals near Onondaga lake, historical evidence of abundance, 69
Mammoth, northern, 68
Manheim dikes bibliography, 55
Manlius, 12, 17, 29, 61
Manlius Center, 16
Manlius limestone, 6, 17, 28, 29, 39, 60; use for building stone, 26
Marcellus, 39
Marcellus shale, 6, 24, 38, 39; faunas, 63
Marl, 34
Meristella cf. laevis, 61
  nasuta, 62
Miller, W. J., cited, 11
Montezuma swamp district, 10
Mount Olympus, 43
Muck, 34

Newland, D. H., cited, 7, 8
Niagara limestone, 9
Niagara shale, 8
Niagaran formations, fossils, 57
Niagaran group, 7
Ninemile creek, 43

Digitized by Google

Odocoileus americanus, 65
Oneida lake, 44
Oneida river, 43, 44
Onondaga creek, 41, 43
Onondaga lake, 44; historical evidence of abundance of mammals in vicinity of, 69; mammalian remains near, 64
Onondaga limestone, 6, 22, 27, 29, 39; building stone, 26; fauna, 62
Onondaga salt group, 10, 31
Ontario Lake plain, 43
Onychodus, 63
Orbiculoidea cf. discus, 61
Oriskany sandstone, 6, 20; fossils, 61
Orthis hipparionyx, 21
Orthoceras *sp.*, 58
annulatum, 58
cancellatum, 58
marcellensis, 63
Orthonota curta, 58
Oswego river, 43, 44
Osborn, H. F., cited, 72

Peat, 34
Peridotite dikes, 45
Phacops cristata, 62
Phoenix, 57
Pholidops squamiformis, 58
Physiographic features, 40
Pittsford shale, 6, 10, 58
Plates, explanations of, 73
Platyceras, 62
Platyostoma turbinata, 62
ventricosa, 62
Plectambonites transversalis, 58
Prosser, C. S., cited, 8, 10
Pterinea communis, 61

Quicklime, 29

Railway ballast, 26
Rensselaeria ovoides, 21, 62
Retepora angulata, 58
Rochester shale, 6, 7
Rock Cut Stone Company, 26, 28
Rock salt, 31
Rockwell springs, 21, 44
Rondout limestone, 6, 16, 59, 60; inferior for building stone, 26
Rusophycus bilobatus, 58

Salina beds, 6, 10, 58
Salina group, 10, 31
Salt, 31
Sand, 29
Schneider, Philip F., acknowledgments to, 72; cited, 40, 48, 49
Schuchert, Charles, cited, 17, 63
Seneca Falls, 59
Seneca limestone, 22, 24
Shale, 37
Shimer, cited, 60
Smallwood, W. M., acknowledgments to, 72; cited, 65, 66
Smith, Burnett, mammalian remains near Onondaga lake, 64; notes on fossils, 57; cited, 52
Smith, DeCost, acknowledgments to, 72
Smith, Mrs Ethel Ostrander, acknowledgments to, 72
Smyth, C. H. jr, cited, 48
Soils, 38
Solvay Process Company, 28, 33
Spirifer arenosus, 21, 61
arrectus, 61
crispus var. corallinensis, 59
cyclopterus, 61
niagarensis, 58
radiatus, 58
vanuxemi, 19, 59, 60
Split Rock, 60
Split Rock quarries, 13, 19, 20, 21, 28, 62
Stokes, H. N., cited, 49
Stratigraphy, 7
Stromatopora, 19, 20
Stropheodonta becki, 61
bipartita, 59
varistriata, 60
Strophostylus varians, 62
Structural geology, 38
Styliolina fissurella, 63
Swamp deposits, 34

Digitized by Google

Syracuse dike, 45, 49, 53
Syracuse salt horizon, 32

Tentaculites elongatus, 61
gyracanthus, 60
Terraces, 42
Three River point, 7, 9, 44, 58
Trematospira formosa, 61

Underwood, Lucien M., cited, 67
Union Springs, 59
Ursus americanus, 65, 74

Vanuxem, Lardner, cited, 14, 16, 17, 45, 46
Vernon shale, 6, 10, 31, 37, 59

Warner, 12, 37
White lake, 44
Whitfieldella nucleolata, 59
Williams, George H., cited, 48

Zaphrentis, 62

Digitized by Google

Digitized by Google

Digitized by Google

The University of the State of New York

New York State Museum

JOHN M. CLARKE, Director

PUBLICATIONS

Packages will be sent prepaid except when distance or weight renders the same impracticable. On 10 or more copies of any one publication 20% discount will be given. Editions printed are only large enough to meet special claims and probable sales. When the sale copies are exhausted, the price for the few reserve copies is advanced to that charged by second-hand booksellers, in order to limit their distribution to cases of special need. Such prices are inclosed in [ ]. All publications are in paper covers, unless binding is specified. Checks or money orders should be addressed and payable to The University of the State of New York.

Museum annual reports 1847–date. *All in print to* 1894, 50c *a volume*, 75c *in cloth; 1894–date, sold in sets only;* 75c *each for octavo volumes; price of quarto volumes on application.*

These reports are made up of the reports of the Director, Geologist, Paleontologist, Botanist and Entomologist, and museum bulletins and memoirs issued as advance sections of the reports.

Director's annual reports 1904–date.

1904.	138p. 20c.	1909.	230p. 41pl. 2 maps, 4 charts. *Out of print*
1905.	102p. 23pl. 30c.	1910.	280p. il. 42pl. 50c.
1906.	186p. 41pl. 25c.	1911.	218p. 49pl. 50c.
1907.	212p. 63pl. 50c.	1912.	214p. 50pl. 50c.
1908.	234p. 39pl. map. 40c.		

These reports cover the reports of the State Geologist and of the State Paleontologist. Bound also with the museum reports of which they form a part.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, 8vo; 2, 14–16, 4to.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–84, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

Report	*Price*	*Report*	*Price*	*Report*	*Price*
12 (1892)	$.50	17	$.75	21	$.40
14	.75	18	.75	22	.40
15, 2v.	2	19	.40	23	.45
16	1	20	.50	[*See* Director's annual reports]	

Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with the Director's report.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882–date.

Reports 3–20 bound also with museum reports 40–46, 48–58 of which they form a part. Since 1898 these reports have been issued as bulletins. Reports 3–4, 17 are out of print, other reports with prices are:

Report	*Price*	*Report*	*Price*	*Report*	*Price*
1	$.50	11	$.25	21 (Bul. 104)	$.25
2	.30	12	.25	22 (" 110)	.25
5	.25	13	*Out of print*	23 (" 124)	.75
6	.15	14 (Bul. 23)	.20	24 (" 134)	.35
7	.20	15 (" 31)	.15	25 (" 141)	.35
8	.25	16 (" 36)	.25	26 (" 147)	.35
9	.25	18 (" 64)	.20	27 (" 155)	.40
10	.35	19 (" 67)	.15	28 (" 165)	.40
		20 (" 97)	.40		

Digitized by Google

Reports 2, 8–12 may also be obtained bound in cloth at 25c each in addition to the price given above.

Botanist's annual reports 1867–date.

Bound also with museum reports 21–date of which they form a part; the first Botanist's report appeared in the 21st museum report and is numbered 21. Reports 21–24, 29, 31–41 were not published separately.

Separate reports for 1871–74, 1876, 1888–98 are out of print. Report for 1899 may be had for 20c; 1900 for 50c. Since 1901 these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), in volume 4 of the 56th (1902), in volume 2 of the 57th (1903), in volume 4 of the 58th (1904), in volume 2 of the 59th (1905), in volume 1 of the 60th (1906), in volume 2 of the 61st (1907), 62d (1908), 63d (1909), 64th (1910), 65th (1911) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum Memoir 4.

Museum bulletins 1887–date. 8vo. *To advance subscribers, $2 a year, or $1 a year for division* (1) *geology, economic geology, paleontology, mineralogy; 50c each for division* (2) *general zoology, archeology, miscellaneous,* (3) *botany,* (4) *entomology.*

Bulletins are grouped in the list on the following pages according to divisions. The divisions to which bulletins belong are as follows:

1 Zoology	58 Mineralogy	115 Geology
2 Botany	59 Entomology	116 Botany
3 Economic Geology	60 Zoology	117 Archeology
4 Mineralogy	61 Economic Geology	118 Geology
5 Entomology	62 Miscellaneous	119 Economic Geology
6 "	63 Geology	120 "
7 Economic Geology	64 Entomology	121 Director's report for 1907
8 Botany	65 Paleontology	122 Botany
9 Zoology	66 Miscellaneous	123 Economic Geology
10 Economic Geology	67 Botany	124 Entomology
11 "	68 Entomology	125 Archeology
12 "	69 Paleontology	126 Geology
13 Entomology	70 Mineralogy	127 "
14 Geology	71 Zoology	128 "
15 Economic Geology	72 Entomology	129 Entomology
16 Archeology	73 Archeology	130 Zoology
17 Economic Geology	74 Entomology	131 Botany
18 Archeology	75 Botany	132 Economic Geology
19 Geology	76 Entomology	133 Director's report for 1908
20 Entomology	77 Geology	134 Entomology
21 Geology	78 Archeology	135 Geology
22 Archeology	79 Entomology	136 Entomology
23 Entomology	80 Paleontology	137 Geology
24 "	81 Geology	138 "
25 Botany	82 "	139 Botany
26 Entomology	83 "	140 Director's report for 1909
27 "	84 "	141 Entomology
28 Botany	85 Economic Geology	142 Economic Geology
29 Zoology	86 Entomology	143 "
30 Economic Geology	87 Archeology	144 Archeology
31 Entomology	88 Zoology	145 Geology
32 Archeology	89 Archeology	146 "
33 Zoology	90 Paleontology	147 Entomology
34 Geology	91 Zoology	148 Geology
35 Economic Geology	92 Paleontology	149 Director's report for 1910
36 Entomology	93 Economic Geology	150 Botany
37 "	94 Botany	151 Economic Geology
38 Zoology	95 Geology	152 Geology
39 Paleontology	96 "	153 "
40 Zoology	97 Entomology	154 "
41 Archeology	98 Mineralogy	155 Entomology
42 Geology	99 Paleontology	156 "
43 Zoology	100 Economic Geology	157 Botany
44 Economic Geology	101 Paleontology	158 Director's report for 1911
45 Paleontology	102 Economic Geology	159 Geology
46 Entomology	103 Entomology	160 "
47 "	104 "	161 Economic Geology
48 Geology	105 Botany	162 Geology
49 Paleontology	106 Geology	163 Archeology
50 Archeology	107 Geology and Paleontology	164 Director's report for 1912
51 Zoology	108 Archeology	165 Entomology
52 Paleontology	109 Entomology	166 Economic Geology
53 Entomology	110 "	167 Botany
54 Botany	111 Geology	168 Geology
55 Archeology	112 Economic Geology	169 "
56 Geology	113 Archeology	170 "
57 Entomology	114 Geology	171 "

Digitized by Google

Bulletins are also found with the annual reports of the museum as follows:

Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
12–15	48, v. 1	78	57, v. 2	116	60, v. 1	150	64, v. 2
16, 17	50, v. 1	79	57, v. 1, pt 2	117	60, v. 3	151	64, v. 2
18, 19	51, v. 1	80	57, v. 1, pt 1	118	60, v. 1	152	64, v. 2
20–25	52, v. 1	81, 82	58, v. 3	119–21	61, v. 1	153	64, v. 2
26–31	53, v. 1	83, 84	58, v. 1	122	61, v. 2	154	64, v. 2
32–34	54, v. 1	85	58, v. 2	123	61, v. 1	155	65, v. 2
35, 36	54, v. 2	86	58, v. 5	124	61, v. 2	156	65, v. 2
37–44	54, v. 3	87–89	58, v. 4	125	62, v. 3	157	65, v. 2
45–48	54, v. 4	90	58, v. 3	126–28	62, v. 1	158	65, v. 1
49–54	55, v. 1	91	58, v. 4	129	62, v. 2	159	65, v. 1
55	56, v. 4	92	58, v. 3	130	62, v. 3	160	65, v. 1
56	56, v. 1	93	58, v. 2	131, 132	62, v. 2	161	65, v. 2
57	56, v. 3	94	58, v. 4	133	62, v. 1	162	65, v. 1
58	56, v. 1	95, 96	58, v. 1	134	62, v. 2		
59, 60	56, v. 3	97	58, v. 5	135	63, v. 1	*Memoir*	
61	56, v. 1	98, 99	59, v. 2	136	63, v. 2	2	49, v. 3
62	56, v. 4	100	59, v. 1	137	63, v. 1	3, 4	53, v. 2
63	56, v. 2	101	59, v. 2	138	63, v. 1	5, 6	57, v. 3
64	56, v. 3	102	59, v. 1	139	63, v. 2	7	57, v. 4
65	56, v 2	103–5	59, v. 2	140	63, v. 1	8, pt 1	59, v. 3
66, 67	56, v. 4	106	59, v. 1	141	63, v. 2	8, pt 2	59, v. 4
68	56, v. 3	107	60, v. 2	142	63, v. 2	9, pt 1	60, v. 4
69	56, v. 2	108	60, v. 3	143	63, v. 2	9, pt 2	62, v. 4
70, 71	57, v. 1, pt 1	109, 110	60, v. 1	144	64, v. 2	10	60, v. 5
72	57, v. 1, pt 2	111	60, v. 2	145	64, v. 1	11	61, v. 3
73	57, v. 2	112	60, v. 1	146	64, v. 1	12	63, v. 3
74	57, v. 1, pt 3	113	60, v. 3	147	64, v. 2	13	63, v. 4
75	57, v. 2	114	60, v. 1	148	64, v. 2	14, v. 1	65, v. 3
76	57, v. 1, pt 2	115	60, v. 2	149	64, v. 1	14, v. 2	65, v. 4
77	57, v. 1, pt 1						

The figures at the beginning of each entry in the following list indicate its number as a museum bulletin.

Geology and Paleontology. 14 Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co., N. Y., with notes on the iron mines. 38p. il. 7pl. 2 maps. Sept. 1895. Free.

19 Merrill, F. J. H. Guide to the Study of the Geological Collections of the New York State Museum. 164p. 119pl. map. Nov. 1898. *Out of print.*

21 Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sept. 1898. Free.

34 Cumings, E. R. Lower Silurian System of Eastern Montgomery County; Prosser, C. S. Notes on the Stratigraphy of Mohawk Valley and Saratoga County, N. Y. 74p. 14pl. map. May 1900. 15c.

39 Clarke, J. M.; Simpson, G. B. & Loomis, F. B. Paleontologic Papers 1. 72p. il. 16pl. Oct. 1900. 15c.

Contents: Clarke, J. M. A Remarkable Occurrence of Orthoceras in the Oneonta Beds of the Chenango Valley, N. Y.
—— Paropsonema cryptophya; a Peculiar Echinoderm from the Intumescens-zone (Portage Beds) of Western New York.
—— Dictyonine Hexactinellid Sponges from the Upper Devonic of New York.
—— The Water Biscuit of Squaw Island, Canandaigua Lake, N. Y.
Simpson, G. B. Preliminary Descriptions of New Genera of Paleozoic Rugose Corals.
Loomis, F. B. Siluric Fungi from Western New York.

42 Ruedemann, Rudolf. Hudson River Beds near Albany and their Taxonomic Equivalents. 116p. 2pl. map. Apr. 1901. 25c.

45 Grabau, A. W. Geology and Paleontology of Niagara Falls and Vicinity. 286p. il. 18pl. map. Apr. 1901. 65c; *cloth*, 90c.

48 Woodworth, J. B. Pleistocene Geology of Nassau County and Borough of Queens. 58p. il. 8pl. map. Dec. 1901. 25c.

49 Ruedemann, Rudolf; Clarke, J. M. & Wood, Elvira. Paleontologic Papers 2. 240p. 13pl. Dec. 1901. *Out of print.*

Contents: Ruedemann, Rudolf. Trenton Conglomerate of Rysedorph Hill.
Clarke, J. M. Limestones of Central and Western New York interbedded with Bituminous Shales of the Marcellus Stage.
Wood, Elvira. Marcellus Limestones of Lancaster, Erie Co., N. Y.
Clarke, J. M. New Agelacrinites.
—— Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonic of New York, Ireland and the Rhineland.

52 Clarke, J. M. Report of the State Paleontologist 1901. 280p. il. 10pl. map, 1 tab. July 1902. 40c.

56 Merrill, F. J. H. Description of the State Geologic Map of 1901. 42p. 2 maps, tab. Nov. 1902. Free.

Digitized by Google

63 Clarke, J. M. & Luther, D. D. Stratigraphy of Canandaigua and Naples Quadrangles. 78p. map. June 1904. 25c.

65 Clarke, J. M. Catalogue of Type Specimens of Paleozoic Fossils in the New York State Museum. 848p. May 1903. $1.20, *cloth.*

69 —— Report of the State Paleontologist 1902. 464p. 52pl. 7 maps. Nov. 1903. $1, *cloth.*

77 Cushing, H. P. Geology of the Vicinity of Little Falls, Herkimer Co. 98p. il. 15pl. 2 maps. Jan. 1905. 30c.

80 Clarke, J. M. Report of the State Paleontologist 1903. 396p. 29pl. 2 maps. Feb. 1905. 85c, *cloth.*

81 Clarke, J. M. & Luther, D. D. Watkins and Elmira Quadrangles. 32p. map. Mar. 1905. 25c.

82 —— Geologic Map of the Tully Quadrangle. 40p. map. Apr. 1905. 20c.

83 Woodworth, J. B. Pleistocene Geology of the Mooers Quadrangle. 62p. 25pl. map. June 1905. 25c.

84 —— Ancient Water Levels of the Champlain and Hudson Valleys. 206p. il. 11pl. 18 maps. July 1905. 45c.

90 Ruedemann, Rudolf. Cephalopoda of Beekmantown and Chazy Formations of Champlain Basin. 224p. il. 38pl. May 1906. 75c, *cloth.*

92 Grabau, A. W. Guide to the Geology and Paleontology of the Schoharie Region. 314p. il. 26pl. map. Apr. 1906. 75c, *cloth.*

95 Cushing, H. P. Geology of the Northern Adirondack Region. 188p. 15pl. 3 maps. Sept. 1905. 30c.

96 Ogilvie, I. H. Geology of the Paradox Lake Quadrangle. 54p. il. 17pl. map. Dec. 1905. 30c.

99 Luther, D. D. Geology of the Buffalo Quadrangle. 32p. map. May 1906. 20c.

101 —— Geology of the Penn Yan-Hammondsport Quadrangles. 28p. map. July 1906. *Out of print.*

106 Fairchild, H. L. Glacial Waters in the Erie Basin. 88p. 14pl. 9 maps. Feb. 1907. *Out of print.*

107 Woodworth, J. B.; Hartnagel, C. A.; Whitlock, H. P.; Hudson, G. H.; Clarke, J. M.; White, David & Berkey, C. P. Geological Papers. 388p. 54pl. map. May 1907. 90c, *cloth.*

Contents: Woodworth, J. B. Postglacial Faults of Eastern New York.
Hartnagel, C. A. Stratigraphic Relations of the Oneida Conglomerate.
—— Upper Siluric and Lower Devonic Formations of the Skunnemunk Mountain Region.
Whitlock, H. P. Minerals from Lyon Mountain, Clinton Co.
Hudson, G. H. On Some Pelmatozoa from the Chazy Limestone of New York.
Clarke, J. M. Some New Devonic Fossils.
—— An Interesting Style of Sand-filled Vein.
—— Eurypterus Shales of the Shawangunk Mountains in Eastern New York.
White, David. A Remarkable Fossil Tree Trunk from the Middle Devonic of New York.
Berkey, C. P. Structural and Stratigraphic Features of the Basal Gneisses of the Highlands.

111 Fairchild, H. L. Drumlins of New York. 60p. 28pl. 19 maps. July 1907. *Out of print.*

114 Hartnagel, C. A. Geologic Map of the Rochester and Ontario Beach Quadrangles. 36p. map. Aug. 1907. 20c.

115 Cushing, H. P. Geology of the Long Lake Quadrangle. 88p. 20pl. map. Sept. 1907. *Out of print.*

118 Clarke, J. M. & Luther, D. D. Geologic Maps and Descriptions of the Portage and Nunda Quadrangles including a map of Letchworth Park. 50p. 16pl. 4 maps. Jan. 1908. 35c.

126 Miller, W. J. Geology of the Remsen Quadrangle. 54p. il. 11pl. map. Jan. 1909. 25c.

127 Fairchild, H. L. Glacial Waters in Central New York. 64p. 27pl. 15 maps. Mar. 1909. 40c.

128 Luther, D. D. Geology of the Geneva-Ovid Quadrangles. 44p. map. Apr. 1909. 20c.

135 Miller, W. J. Geology of the Port Leyden Quadrangle, Lewis County, N. Y. 62p. il. 11pl. map. Jan. 1910. 25c.

137 Luther, D. D. Geology of the Auburn-Genoa Quadrangles. 36p. map. Mar. 1910. 20c.

138 Kemp, J. F. & Ruedemann, Rudolf. Geology of the Elizabethtown and Port Henry Quadrangles. 176p. il. 20pl. 3 maps. Apr. 1910. 40c.

Digitized by Google

145 Cushing, H. P.; Fairchild, H. L.; Ruedemann, Rudolf & Smyth, C. H. Geology of the Thousand Islands Region. 194p. il. 62pl. 6 maps. Dec. 1910. 75c.
146 Berkey, C. P. Geologic Features and Problems of the New York City (Catskill) Aqueduct. 286p. il. 38pl. maps. Feb. 1911. 75c; *cloth*, $1.
148 Gordon, C. E. Geology of the Poughkeepsie Quadrangle. 122p. il. 26pl. map. Apr. 1911. 30c.
152 Luther, D. D. Geology of the Honeoye-Wayland Quadrangles. 30p. map. Oct. 1911. 20c.
153 Miller, William J. Geology of the Broadalbin Quadrangle, Fulton-Saratoga Counties, New York. 66p. il. 8 pl. map. Dec. 1911. 25c.
154 Stoller, James H. Glacial Geology of the Schenectady Quadrangle. 44p. 9 pl. map. Dec. 1911. 20c.
159 Kemp, James F. The Mineral Springs of Saratoga. 80p. il. 3pl. Apr. 1912. 15c.
160 Fairchild, H. L. Glacial Waters in the Black and Mohawk Valleys. 48p. il. 8pl. 14 maps. May 1912. 50c.
162 Ruedemann, Rudolf. The Lower Siluric Shales of the Mohawk Valley. 152p. il. 15pl. Aug. 1912. 35c.
168 Miller, William J. Geological History of New York State. 130p. 43pl. 10 maps. Dec. 1913. 40c.
169 Cushing, H. P. & Ruedemann, Rudolf. Geology of Saratoga Springs and Vicinity. 178p. il. 20 pl. map. Feb. 1914. 40c.
170 Miller, William J. Geology of the North Creek Quadrangle. 90p. il. 14pl. Feb. 1914. 25c.
171 Hopkins, T. C. The Geology of the Syracuse Quadrangle. 80p. il. 20pl. map. July 1914. 25c.
Luther, D. D. Geology of the Attica and Depew Quadrangles. *In press.*
Luther, D. D. Geology of the Phelps Quadrangle. *In preparation.*
Whitnall, H. O. Geology of the Morrisville Quadrangle. *Prepared.*
Hopkins, T. C. Geology of the Syracuse Quadrangle. *In press.*
Hudson, G. H. Geology of Valcour Island. *In preparation.*

Economic Geology. 3 Smock, J. C. Building Stone in the State of New York. 154p. Mar. 1888. *Out of print.*
7 —— First Report on the Iron Mines and Iron Ore Districts in the State of New York. 78p. map. June 1889. *Out of print.*
10 —— Building Stone in New York. 210p. map, tab. Sept. 1890. 40c.
11 Merrill, F. J. H. Salt and Gypsum Industries of New York. 94p. 12pl. 2 maps, 11 tab. Apr. 1893. [50c]
12 Ries, Heinrich. Clay Industries of New York. 174p. il. 1pl. map. Mar. 1895. 30c.
15 Merrill, F. J. H. Mineral Resources of New York. 240p. 2 maps. Sept. 1895. [50c]
17 —— Road Materials and Road Building in New York. 52p. 14pl. 2 maps. Oct. 1897. 15c.
30 Orton, Edward. Petroleum and Natural Gas in New York. 136p. il. 3 maps. Nov. 1899. 15c.
35 Ries, Heinrich. Clays of New York; their Properties and Uses. 456p. 140pl. map. June 1900. *Out of print.*
44 —— Lime and Cement Industries of New York; Eckel, E. C. Chapters on the Cement Industry. 332p. 101pl. 2 maps. Dec. 1901. 85c, *cloth.*
61 Dickinson, H. T. Quarries of Bluestone and Other Sandstones in New York. 114p. 18pl. 2 maps. Mar. 1903. 35c.
85 Rafter, G. W. Hydrology of New York State. 902p. il. 44pl. 5 maps. May 1905. $1.50, *cloth.*
93 Newland, D. H. Mining and Quarry Industry of New York. 78p. July 1905. *Out of print.*
100 McCourt, W. E. Fire Tests of Some New York Building Stones. 40p. 26pl. Feb. 1906. 15c.
102 Newland, D. H. Mining and Quarry Industry of New York 1905. 162p. June 1906. 25c.
112 —— Mining and Quarry Industry of New York 1906. 82p. July 1907. *Out of print.*

Digitized by Google

119 —— & Kemp, J. F. Geology of the Adirondack Magnetic Iron Ores with a Report on the Mineville-Port Henry Mine Group. 184p. 14pl. 8 maps. Apr. 1908. 35c.
120 Newland, D. H. Mining and Quarry Industry of New York 1907. 82p. July 1908. *Out of print.*
123 —— & Hartnagel, C. A. Iron Ores of the Clinton Formation in New York State. 76p. il. 14pl. 3 maps. Nov. 1908. 25c.
132 Newland, D. H. Mining and Quarry Industry of New York 1908. 98p. July 1909. 15c.
142 —— Mining and Quarry Industry of New York for 1909. 98p. Aug. 1910. 15c.
143 —— Gypsum Deposits of New York. 94p. 20pl. 4 maps. Oct. 1910 35c.
151 —— Mining and Quarry Industry of New York 1910. 82p. June 1911. 15c.
161 —— Mining and Quarry Industry of New York 1911. 114p. July 1912. 20c.
166 —— Mining and Quarry Industry of New York 1912. 114p. August 1913. 20c.

Mineralogy. 4 Nason, F. L. Some New York Minerals and their Localities. 22p. 1pl. Aug. 1888. Free.
58 Whitlock, H. P. Guide to the Mineralogic Collections of the New York State Museum. 150p. il. 39pl. 11 models. Sept. 1902. 40c.
70 —— New York Mineral Localities. 110p. Oct. 1903. 20c.
98 —— Contributions from the Mineralogic Laboratory. 38p. 7pl. Dec. 1905. *Out of print.*

Zoology. 1 Marshall, W. B. Preliminary List of New York Unionidae. 20p. Mar. 1892. Free.
9 —— Beaks of Unionidae Inhabiting the Vicinity of Albany, N. Y. 30p. 1pl. Aug. 1890. Free.
29 Miller, G. S., jr. Preliminary List of New York Mammals. 124p. Oct. 1899. 15c.
33 Farr, M. S. Check List of New York Birds. 224p. Apr. 1900. 25c.
38 Miller, G. S., jr. Key to the Land Mammals of Northeastern North America. 106p. Oct. 1900. *Out of print.*
40 Simpson, G. B. Anatomy and Physiology of Polygyra albolabris and Limax maximus and Embryology of Limax maximus. 82p. 28pl. Oct. 1901. 25c.
43 Kellogg, J. L. Clam and Scallop Industries of New York. 36p. 2pl. map. Apr. 1901. Free.
51 Eckel, E. C. & Paulmier, F. C. Catalogue of Reptiles and Batrachians of New York. 64p. il. 1pl. Apr. 1902. *Out of print.*

Eckel, E. C. Serpents of Northeastern United States.
Paulmier, F. C. Lizards, Tortoises and Batrachians of New York.

60 Bean, T. H. Catalogue of the Fishes of New York. 784p. Feb. 1903. $1, *cloth.*
71 Kellogg, J. L. Feeding Habits and Growth of Venus mercenaria. 30p. 4pl. Sept. 1903. Free.
88 Letson, Elizabeth J. Check List of the Mollusca of New York. 116p. May 1905. 20c.
91 Paulmier, F. C. Higher Crustacea of New York City. 78p. il. June 1905. 20c.
130 Shufeldt, R. W. Osteology of Birds. 382p. il. 26pl. May 1909. 50c.

Entomology. 5 Lintner, J. A. White Grub of the May Beetle. 34p. il. Nov. 1888. Free.
6 —— Cut-worms. 38p. il. Nov. 1888. Free.
13 —— San José Scale and Some Destructive Insects of New York State. 54p. 7pl. Apr. 1895. 15c.
20 Felt, E. P. Elm Leaf Beetle in New York State. 46p. il. 5pl. June 1898. Free.

See 57.

23 —— 14th Report of the State Entomologist 1898. 150p. il. 9pl. Dec. 1898. 20c.
24 —— Memorial of the Life and Entomologic Work of J. A. Lintner Ph.D. State Entomologist 1874–98; Index to Entomologist's Reports 1–13. 316p. 1pl. Oct. 1899. 35c.

Supplement to 14th report of the State Entomologist.

Digitized by Google

26 —— Collection, Preservation and Distribution of New York Insects. 36p. il. Apr. 1899. *Out of print.*

27 —— Shade Tree Pests in New York State. 26p. il. 5pl. May 1899. Free.

31 —— 15th Report of the State Entomologist 1899. 128p. June 1900. 15c.

36 —— 16th Report of the State Entomologist 1900. 118p. 16pl. Mar. 1901. 25c.

37 —— Catalogue of Some of the More Important Injurious and Beneficial Insects of New York State. 54p. il. Sept. 1900. Free.

46 —— Scale Insects of Importance and a List of the Species in New York State. 94p. il. 15pl. June 1901. 25c.

47 Needham, J. G. & Betten, Cornelius. Aquatic Insects in the Adirondacks. 234p. il. 36pl. Sept. 1901. 45c.

53 Felt, E. P. 17th Report of the State Entomologist 1901. 232p. il. 6pl. Aug. 1902. *Out of print*

57 —— Elm Leaf Beetle in New York State. 46p. il. 8pl. Aug. 1902. *Out of print.*

This is a revision of Bulletin 20 containing the more essential facts observed since that was prepared.

59 —— Grapevine Root Worm. 40p. 6pl. Dec. 1902. 15c.

See 72.

64 —— 18th Report of the State Entomologist 1902. 110p. 6pl. May 1903. 20c.

68 Needham, J. G. *& others.* Aquatic Insects in New York. 322p. 52pl. Aug. 1903. 80c, *cloth.*

72 Felt, E. P. Grapevine Root Worm. 58p. 13pl. Nov. 1903. 20c.

This is a revision of Bulletin 59 containing the more essential facts observed since that was prepared.

74 —— & Joutel, L. H. Monograph of the Genus Saperda. 88p. 14pl. June 1904. 25c.

76 Felt, E. P. 19th Report of the State Entomologist 1903. 150p. 4pl. 1904. 15c.

79 —— Mosquitos or Culicidae of New York. 164p. il. 57pl. tab. Oct. 1904. 40c.

86 Needham, J. G. *& others.* May Flies and Midges of New York. 352p. il. 37pl. June 1905. *Out of print.*

97 Felt, E. P. 20th Report of the State Entomologist 1904. 246p. il. 19pl. Nov. 1905. 40c.

103 —— Gipsy and Brown Tail Moths. 44p. 10pl. July 1906. 15c.

104 —— 21st Report of the State Entomologist 1905. 144p. 10pl. Aug. 1906. 25c.

109 —— Tussock Moth and Elm Leaf Beetle. 34p. 8pl. Mar. 1907. 20c.

110 —— 22d Report of the State Entomologist 1906. 152p. 3pl. June 1907. 25c.

124 —— 23d Report of the State Entomologist 1907. 542p. il. 44pl. Oct. 1908. 75c.

129 —— Control of Household Insects. 48p. il. May 1909. *Out of print.*

134 —— 24th Report of the State Entomologist 1908. 208p. il. 17pl. Sept. 1909. 35c.

136 —— Control of Flies and Other Household Insects. 56p. il. Feb. 1910. 15c.

This is a revision of Bulletin 129 containing the more essential facts observed since that was prepared.

141 Felt, E. P. 25th Report of the State Entomologist 1909. 178p. il. 22pl. July 1910. 35c.

147 —— 26th Report of the State Entomologist 1910. 182p. il. 35pl. Mar. 1911. 35c.

155 —— 27th Report of the State Entomologist 1911. 198p. il. 27pl. Jan. 1912. 40c.

156 —— Elm Leaf Beetle and White-Marked Tussock Moth. 35p. 8pl. Jan. 1912. 20c.

165 —— 28th Report of the State Entomologist 1912. 266p. 14pl. July 1913. 40c.

Digitized by Google

Needham, J. G. Monograph on Stone Flies. *In preparation.*

Botany. 2 Peck, C. H. Contributions to the Botany of the State of New York. 72p. 2pl. May 1887. *Out of print.*

8 —— Boleti of the United States. 98p. Sept. 1889. *Out of print.*

25 —— Report of the State Botanist 1898. 76p. 5pl. Oct. 1899. *Out of print.*

28 —— Plants of North Elba. 206p. map. June 1899. 20c.

54 —— Report of the State Botanist 1901. 58p. 7pl. Nov. 1902. 40c.

67 —— Report of the State Botanist 1902. 196p. 5pl. May 1903. 50c.

75 —— Report of the State Botanist 1903. 70p. 4pl. 1904. 40c.

94 —— Report of the State Botanist 1904. 60p. 10pl. July 1905. 40c.

105 —— Report of the State Botanist 1905. 108p. 12pl. Aug. 1906. 50c.

116 —— Report of the State Botanist 1906. 120p. 6pl. July 1907. 35c.

122 —— Report of the State Botanist 1907. 178p. 5pl. Aug. 1908. 40c.

131 —— Report of the State Botanist 1908. 202p. 4pl. July 1909. 40c.

139 —— Report of the State Botanist 1909. 116p. 10pl. May 1910. 45c.

150 —— Report of the State Botanist 1910. 100p. 5pl. May 1911. 30c.

157 —— Report of the State Botanist 1911. 139p. 9pl. Mar. 1912. 35c.

167 —— Report of the State Botanist 1912. 138p. 4pl. Sept. 1913. 30c.

Archeology. 16 Beauchamp, W. M. Aboriginal Chipped Stone Implements of New York. 86p. 23pl. Oct. 1897. 25c.

18 —— Polished Stone Articles Used by the New York Aborigines. 104p. 35pl. Nov. 1897. 25c.

22 —— Earthenware of the New York Aborigines. 78p. 33pl. Oct. 1898. 25c.

32 —— Aboriginal Occupation of New York. 190p. 16pl. 2 maps. Mar. 1900. 30c.

41 —— Wampum and Shell Articles Used by New York Indians. 166p. 28pl. Mar. 1901. *Out of print.*

50 —— Horn and Bone Implements of the New York Indians. 112p. 43pl. Mar. 1902. *Out of print.*

55 —— Metallic Implements of the New York Indians. 94p. 38pl. June 1902. 25c.

73 —— Metallic Ornaments of the New York Indians. 122p. 37pl. Dec. 1903. 30c.

78 —— History of the New York Iroquois. 340p. 17pl. map. Feb. 1905. 75c, *cloth.*

87 —— Perch Lake Mounds. 84p. 12pl. Apr. 1905. *Out of print.*

89 —— Aboriginal Use of Wood in New York. 190p. 35pl. June 1905. 35c.

108 —— Aboriginal Place Names of New York. 336p. May 1907. 40c.

113 —— Civil, Religious and Mourning Councils and Ceremonies of Adoption. 118p. 7pl. June 1907. 25c.

117 Parker, A. C. An Erie Indian Village and Burial Site. 102p. 38pl. Dec. 1907. 30c.

125 Converse, H. M. & Parker, A. C. Iroquois Myths and Legends. 196p. il. 11pl. Dec. 1908. 50c.

144 Parker, A. C. Iroquois Uses of Maize and Other Food Plants. 120p. il. 31pl. Nov. 1910. 30c.

163 —— The Code of Handsome Lake. 144p. 23pl. Nov. 1912. 25c.

Miscellaneous. 62 Merrill, F. J. H. Directory of Natural History Museums in United States and Canada. 236p. Apr. 1903. 30c.

66 Ellis, Mary. Index to Publications of the New York State Natural History Survey and New York State Museum 1837–1902. 418p. June 1903. 75c, *cloth.*

Museum memoirs 1889–date. 4to.

1 Beecher, C. E. & Clarke, J. M. Development of Some Silurian Brachiopoda. 96p. 8pl. Oct. 1889. $1.

2 Hall, James & Clarke, J. M. Paleozoic Reticulate Sponges. 350p. il. 70pl. 1898. $2, *cloth.*

3 Clarke, J. M. The Oriskany Fauna of Becraft Mountain, Columbia Co., N. Y. 128p. 9pl. Oct. 1900. 80c.

4 Peck, C. H. N. Y. Edible Fungi, 1895–99. 106p. 25pl. Nov. 1900. [$1.25]

This includes revised descriptions and illustrations of fungi reported in the 49th, 51st and 52d reports of the State Botanist.

Digitized by Google

5 Clarke, J. M. & Ruedemann, Rudolf. Guelph Formation and Fauna of New York State. 196p. 21pl. July 1903. $1.50, *cloth.*

6 Clarke, J. M. Naples Fauna in Western New York. 268p. 26pl. map. 1904. $2, *cloth.*

7 Ruedemann, Rudolf. Graptolites of New York. Pt 1 Graptolites of the Lower Beds. 350p. 17pl. Feb. 1905. $1.50, *cloth.*

8 Felt, E. P. Insects Affecting Park and Woodland Trees. v.1. 460p. il. 48pl. Feb. 1906. $2.50, *cloth*; v. 2. 548p. il. 22pl. Feb. 1907. $2, *cloth.*

9 Clarke, J. M. Early Devonic of New York and Eastern North America. Pt 1. 366p. il. 70pl. 5 maps. Mar. 1908. $2.50, *cloth*; Pt 2. 250p. il. 36pl. 4 maps. Sept. 1909. $2, *cloth.*

10 Eastman, C. R. The Devonic Fishes of the New York Formations. 236p. 15pl. 1907. $1.25, *cloth.*

11 Ruedemann, Rudolf. Graptolites of New York. Pt 2 Graptolites of the Higher Beds. 584p. il. 31pl. 2 tab. Apr. 1908. $2.50, *cloth.*

12 Eaton, E. H. Birds of New York. v. 1. 501p. il. 42pl. Apr. 1910. $3, *cloth*; v. 2, *in press.*

13 Whitlock, H. P. Calcites of New York. 190p. il. 27pl. Oct. 1910. $1, *cloth.*

14 Clarke, J. M. & Ruedemann, Rudolf. The Eurypterida of New York. v. 1. Text. 440p. il. v. 2 Plates. 188p. 88pl. Dec. 1912. $4, *cloth.*

Natural History of New York. 30v. il. pl. maps. 4to. Albany 1842–94.

DIVISION 1 ZOOLOGY. De Kay, James E. Zoology of New York; or, The New York Fauna; comprising detailed descriptions of all the animals hitherto observed within the State of New York with brief notices of those occasionally found near its borders, and accompanied by appropriate illustrations. 5v. il. pl. maps. sq. 4to. Albany 1842–44. *Out of print.*

Historical introduction to the series by Gov. W. H. Seward. 178p.

v. 1 pt1 Mammalia. 131 + 46p. 33pl. 1842.

300 copies with hand-colored plates.

v. 2 pt2 Birds. 12 + 380p. 141pl. 1844.

Colored plates.

v. 3 pt3 Reptiles and Amphibia. 7 + 98p. pt 4 Fishes. 15 + 415p. 1842.

pt 3–4 bound together.

v. 4 Plates to accompany v. 3. Reptiles and Amphibia. 23pl. Fishes. 79pl. 1842.

300 copies with hand-colored plates.

v. 5 pt5 Mollusca. 4 + 271p. 40pl. pt 6 Crustacea. 70p. 13pl. 1843–44

Hand-colored plates; pt5–6 bound together.

DIVISION 2 BOTANY. Torrey, John. Flora of the State of New York; comprising full descriptions of all the indigenous and naturalized plants hitherto discovered in the State, with remarks on their economical and medical properties. 2v. il. pl. sq. 4to. Albany 1843. *Out of print.*

v. 1 Flora of the State of New York. 12 + 484p. 72pl. 1843.

300 copies with hand-colored plates.

v. 2 Flora of the State of New York. 572p. 89pl. 1843.

300 copies with hand-colored plates.

DIVISION 3 MINERALOGY. Beck, Lewis C. Mineralogy of New York; comprising detailed descriptions of the minerals hitherto found in the State of New York, and notices of their uses in the arts and agriculture. il. pl. sq. 4to. Albany 1842. *Out of print.*

v. 1 pt1 Economical Mineralogy. pt2 Descriptive Mineralogy. 24 + 536p. 1842.

8 plates additional to those printed as part of the text.

DIVISION 4 GEOLOGY. Mather, W. W.; Emmons, Ebenezer; Vanuxem, Lardner & Hall, James. Geology of New York. 4v. il. pl. sq. 4to. Albany 1842–43. *Out of print.*

v. 1 pt1 Mather, W. W. First Geological District. 37 + 653p. 46pl. 1843.

v. 2 pt2 Emmons, Ebenezer. Second Geological District. 10 + 437p. 17pl. 1842.

v. 3 pt3 Vanuxem, Lardner. Third Geological District. 306p. 1842.

Digitized by Google

v. 4 pt4 Hall, James. Fourth Geological District. 22 + 683p. 19pl. map. 1843.

DIVISION 5 AGRICULTURE. Emmons, Ebenezer. Agriculture of New York; comprising an account of the classification, composition and distribution of the soils and rocks and the natural waters of the different geological formations, together with a condensed view of the meteorology and agricultural productions of the State. 5v. il. pl. sq. 4to. Albany 1846–54. *Out of print.*

v. 1 Soils of the State, Their Composition and Distribution. 11 + 371p. 21pl. 1846.

v. 2 Analysis of Soils, Plants, Cereals, etc. 8 + 343 + 46p. 42pl. 1849.
With hand-colored plates.

v. 3 Fruits, etc. 8 + 340p. 1851.

v. 4 Plates to accompany v. 3. 95pl. 1851.
Hand-colored.

v. 5 Insects Injurious to Agriculture. 8 + 272p. 50pl. 1854.
With hand-colored plates.

DIVISION 6 PALEONTOLOGY. Hall, James. Paleontology of New York. 8v. il. pl. sq. 4to. Albany 1847–94. *Bound in cloth.*

v. 1 Organic Remains of the Lower Division of the New York System. 23 + 338p. 99pl. 1847. *Out of print.*

v. 2 Organic Remains of Lower Middle Division of the New York System. 8 + 362p. 104pl. 1852. *Out of print.*

v. 3 Organic Remains of the Lower Helderberg Group and the Oriskany Sandstone. pt 1, text. 12 + 532p. 1859. [$3.50]

—— pt 2. 142pl. 1861. [$2.50]

v. 4 Fossil Brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 11 + 1 + 428p. 69pl. 1867. $2.50.

v. 5 pt 1 Lamellibranchiata 1. Monomyaria of the Upper Helderberg, Hamilton and Chemung Groups. 18 + 268p. 45pl. 1884. $2.50.

—— —— Lamellibranchiata 2. Dimyaria of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 62 + 293p. 51pl. 1885. $2.50.

—— pt 2 Gasteropoda, Pteropoda and Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 2v. 1879. v. 1, text. 15 + 492p.; v.2. 120pl. $2.50 for 2 v.

—— & Simpson, George B. v. 6 Corals and Bryozoa of the Lower and Upper Helderberg and Hamilton Groups. 24 + 298p. 67pl. 1887. $2.50

—— & Clarke, John M. v. 7 Trilobites and Other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. 64 + 236p. 46pl. 1888. Cont. supplement to v. 5, pt 2. Pteropoda, Cephalopoda and Annelida. 42p. 18pl. 1888. $2.50.

—— & Clarke, John M. v. 8 pt 1 Introduction to the Study of the Genera of the Paleozoic Brachiopoda. 16 + 367p. 44pl. 1892. $2.50.

—— & Clarke, John M. v. 8 pt 2 Paleozoic Brachiopoda. 16 + 394p. 64pl. 1894. $2.50.

Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. 8vo. 1853.

Handbooks 1893–date.

New York State Museum. 52p. il. 1902. Free.
Outlines, history and work of the museum with list of staff 1902.

Paleontology. 12p. 1899. *Out of print.*
Brief outline of State Museum work in paleontology under heads: Definition; Relation to biology; Relation to stratigraphy; History of paleontology in New York.

Guide to Excursions in the Fossiliferous Rocks of New York. 124p. 1899. *Out of print.*
Itineraries of 32 trips covering nearly the entire series of Paleozoic rocks, prepared specially for the use of teachers and students desiring to acquaint themselves more intimately with the classic rocks of this State.

Entomology. 16p. 1899. *Out of print.*

Economic Geology. 44p. 1904. Free.

Insecticides and Fungicides. 20p. 1909. Free.

Digitized by Google

Classification of New York Series of Geologic Formations. 32p. 1903. *Out of print.* Revised edition. 96p. 1912. Free.

Geologic maps. Merrill, F. J. H. Economic and Geologic Map of the State of New York; issued as part of Museum Bulletin 15 and 48th Museum Report, v. 1. 59 x 67 cm. 1894. Scale 14 miles to 1 inch. 15c.

—— Map of the State of New York Showing the Location of Quarries of Stone Used for Building and Road Metal. 1897. *Out of print.*

—— Map of the State of New York Showing the Distribution of the Rocks Most Useful for Road Metal. 1897. *Out of print.*

—— Geologic Map of New York. 1901. Scale 5 miles to 1 inch. *In atlas form* $3. *Lower Hudson sheet* 60c.

The lower Hudson sheet, geologically colored, comprises Rockland, Orange, Dutchess, Putnam, Westchester, New York, Richmond, Kings, Queens and Nassau counties, and parts of Sullivan, Ulster and Suffolk counties; also northeastern New Jersey and part of western Connecticut.

—— Map of New York Showing the Surface Configuration and Water Sheds. 1901. Scale 12 miles to 1 inch. 15c.

—— Map of the State of New York Showing the Location of Its Economic Deposits. 1904. Scale 12 miles to 1 inch. 15c.

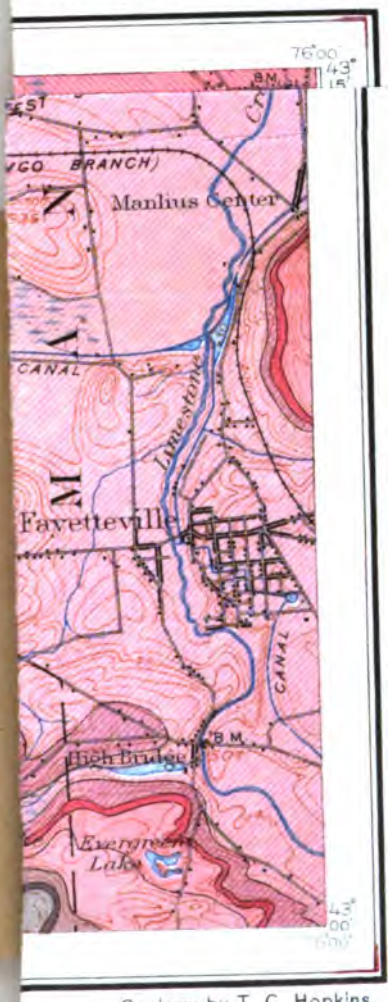
Geologic maps on the United States Geological Survey topographic base. Scale 1 in. = 1 m. Those marked with an asterisk have also been published separately.

*Albany county. 1898. *Out of print.*
Area around Lake Placid. 1898.
Vicinity of Frankfort Hill [parts of Herkimer and Oneida counties]. 1899.
Rockland county. 1899.
Amsterdam quadrangle. 1900.
*Parts of Albany and Rensselaer counties. 1901. *Out of print.*
*Niagara river. 1901. 25c.
Part of Clinton county. 1901.
Oyster Bay and Hempstead quadrangles on Long Island. 1901.
Portions of Clinton and Essex counties. 1902.
Part of town of Northumberland, Saratoga co. 1903.
Union Springs, Cayuga county and vicinity. 1903.
*Olean quadrangle. 1903. Free.
*Becraft Mt with 2 sheets of sections. (Scale 1 in. = ½ m.) 1903. 20c.
*Canandaigua-Naples quadrangles. 1904. 20c.
*Little Falls quadrangle. 1905. Free.
*Watkins-Elmira quadrangles. 1905. 20c.
*Tully quadrangle. 1905. Free.
*Salamanca quadrangle. 1905. Free.
*Mooers quadrangle. 1905. Free.
Paradox Lake quadrangle. 1905
*Buffalo quadrangle. 1906. Free.
*Penn Yan-Hammondsport quadrangles. 1906. 20c.
*Rochester and Ontario Beach quadrangles. 20c.
*Long Lake quadrangle. Free.
*Nunda-Portage quadrangles. 20c.
*Remsen quadrangle. 1908. Free.
*Geneva-Ovid quadrangles. 1909. 20c.
*Port Leyden quadrangle. 1910. Free.
*Auburn-Genoa quadrangles. 1910. 20c.
*Elizabethtown and Port Henry quadrangles. 1910. 15c.
*Alexandria Bay quadrangle. 1910. Free.
*Cape Vincent quadrangle. 1910. Free.
*Clayton quadrangle. 1910. Free.
*Grindstone quadrangle. 1910. Free.
*Theresa quadrangle. 1910. Free.
*Poughkeepsie quadrangle. 1911. Free.
*Honeoye-Wayland quadrangle. 1911. 20c.
*Broadalbin quadrangle. 1911. Free.
*Schenectady quadrangle. 1911. Free.
*Saratoga-Schuylerville quadrangles. 1914. 20c.
*North Creek quadrangle. 1914. Free.
*Syracuse quadrangle. 1914. Free.

Digitized by Google

Digitized by Google

BULLETIN 171
SYRACUSE QUADRANGLE



Geology by T. C. Hopkins.

Digitized by Google

Digitized by Google

S-NA-4

SEP 2 1914
11983

University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the act of August 24, 1912

Published fortnightly

No. 573 ALBANY, N. Y. AUGUST 15, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 172

GEOLOGY OF THE ATTICA-DEPEW QUADRANGLES

BY

D. D. LUTHER

	PAGE
Introduction	5
Description of formations	7
Siluric	7
Devonic	9
Hamilton beds	15
Bibliography	30
Index	31

ALBANY

THE UNIVERSITY OF THE STATE OF NEW YORK

1914

M31r-Mr13-1500

Digitized by Google

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of the University
With years when terms expire

1917 St Clair McKelway M.A. LL.D. D.C.L. L.H.D.
Chancellor Brooklyn
1926 Pliny T. Sexton LL.B. LL.D. *Vice Chancellor* Palmyra
1915 Albert Vander Veer M.D. M.A. Ph.D. LL.D. Albany
1922 Chester S. Lord M.A. LL.D. - - - - New York
1918 William Nottingham M.A. Ph.D. LL.D. - - Syracuse
1921 Francis M. Carpenter - - - - - - Mount Kisco
1923 Abram I. Elkus LL.B. D.C.L. - - - - New York
1924 Adelbert Moot - - - - - - - - - Buffalo
1925 Charles B. Alexander M.A. LL.B. LL.D. Litt.D. Tuxedo
1919 John Moore - - - - - - - - - Elmira
1920 Andrew J. Shipman M.A. LL.B. LL.D. - - New York
1916 Walter Guest Kellogg B.A. - - - - Ogdensburg

President of the University
and Commissioner of Education

John H. Finley M.A. LL.D.

Assistant Commissioners

Augustus S. Downing M.A. L.H.D. LL.D. *For Higher Education*
Charles F. Wheelock B.S. LL.D. *For Secondary Education*
Thomas E. Finegan M.A. Pd.D. LL.D. *For Elementary Education*

Director of State Library

James I. Wyer, Jr, M.L.S.

Director of Science and State Museum

John M. Clarke Ph.D. D.Sc. LL.D.

Chiefs of Divisions

Administration, George M. Wiley M.A.
Attendance, James D. Sullivan
Educational Extension, William R. Watson B.S.
Examinations, Harlan H. Horner B.A.
History, James A. Holden B.A.
Inspections, Frank H. Wood M.A.
Law, Frank B. Gilbert B.A.
Library School, Frank K. Walter M.A. M.L.S.
Public Records, Thomas C. Quinn
School Libraries, Sherman Williams Pd.D.
Statistics, Hiram C. Case
Visual Instruction, Alfred W. Abrams Ph.B.
Vocational Schools, Arthur D. Dean D.Sc.

Digitized by Google

New York State Education Department
Science Division, March 7, 1913

Hon. Andrew S. Draper LL.D.
Commissioner of Education

SIR: I have the honor to submit herewith a manuscript report, with maps, on the *Geology of the Attica and Depew Quadrangles,* and to recommend the publication of this report as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

STATE OF NEW YORK
EDUCATION DEPARTMENT
COMMISSIONER'S ROOM

Approved for publication this the 17th day of March 1913

Commissioner of Education

Digitized by Google

Digitized by Google

University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the act of August 12, 1912

Published fortnightly

No. 573 ALBANY, N. Y. AUGUST 15, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 172

GEOLOGY OF THE ATTICA AND DEPEW QUADRANGLES

BY D. D. LUTHER

The area embraced within these quadrangles lies between the lines of 42° 45′ and 43° north latitude, and 78° 15′ and 78° 45′ west longitude and contains 455 square miles.

It is situated just where the sloping front of the great Allegany plateau begins to bend from a generally east and west line to a direction nearly southwest and parallel to the southern shore of Lake Erie.

The point of lowest altitude is in the northwest corner of the Depew quadrangle where it is 585 feet above sea level, or 338 feet above Lake Ontario and 12 feet higher than Lake Erie, while the crest of the ridge west of Varysburg reaches, on the southern boundary line of the Attica quadrangle, the height of 1780 feet, showing a difference in elevation of 1195 feet.

The rock strata of this region have an average southward dip or declination estimated to be about 33 feet a mile, or 577 feet on a north and south line across the quadrangles. Adding this thickness which is lost from the difference in elevation, the total thickness of the rock section or surface rocks shown on the maps is approximately 1772 feet.

The basal strata of this rock section to the thickness of about 100 feet belong to the Ontaric or Siluric system, and lie at the foot and to the north of the rocky declivity known as the Helderberg escarpment that extends from Albany county to the Niagara river, and crosses the Depew quadrangle near its northern boundary. The Siluric strata and their contact with the overlying basal formation of the Devonic system are finely exposed in several quarries along the front of the escarpment.

The rocks exposed in the upper part of the escarpment and the surface rocks south of it on these quadrangles belong to the

Digitized by Google

Devonic system, all the subdivisions comprising this system in western New York being found within the area covered by the map, though the highest, the Chemung sandstones and shales, is represented by only a fraction of its thickness and over a small area.

The drift sheet or soil mantle on these areas is usually quite thin and rock outcrops are frequent except in the flat region in the northern part of the Attica quadrangle where it is much thicker and rock exposures very rare.

The Mesodevonic Marcellus and lower Hamilton beds are quite well displayed on the Depew quadrangle in the vicinity of Lancaster, along Cayuga creek and other small streams.

The gorges and gullies through which the Tonawanda, Ellicott, Cayuga and Cazenovia creeks and their numerous branches flow, show the stratigraphic details of the upper Hamilton, the Genesee and Portage beds in a manner and to an extent perhaps nowhere else found so conveniently accessible for examination and the collection of their finely preserved and abundant fossils.

The geologic formations of which the surface rocks of these quadrangles are composed and which are represented by the various colors on the map, consist of the following, in descending order:

ERA OR SYSTEM	PERIOD OR GROUP	STAGE OR AGE
Devonic	Chautauquan	Chemung sandstones and shales
		Wiscoy shale
		Nunda sandstone
		Gardeau flags and shales
		Hatch shales and flags
	Senecan	Rhinestreet black shale
		Cashaqua shale
		Middlesex black shale
		West River shale
		Genundewa limestone
		Genesee black shale
		Pyrite in Tully horizon
	Erian	Moscow shale
		Tichenor limestone
		Ludlowville shale
		Skaneateles shale
		Cardiff shale
		Stafford limestone
		Marcellus black shale
	Ulsterian	Onondaga limestone
	Oriskanian	Oriskany sandstone horizon
Siluric	Cayugan	Cobleskill limestone
		Bertie waterlime
		Camillus shale

Digitized by Google

DESCRIPTION OF FORMATIONS IN ASCENDING ORDER FROM NORTH TO SOUTH

SILURIC

CAMILLUS SHALE

The lowest in the series of rock formations shown on the map is the Camillus member of the Cayugan group, 250 to 300 feet thick, composed mainly of soft, light gray marlytes or gypseous shales with frequent thin layers of hard dolomite or magnesian limestone.

The great deposit of rock salt that underlies all southern-central and western New York is at or near the bottom of this formation and the gypsum beds of equal commercial importance, so extensively quarried in Onondaga county and westward to Genesee county, are found in the upper part. It is said that the first discovery of gypsum in the United States was made in 1792 in these beds at Camillus, Onondaga county, when the principal gypsum layer and a large part of the formation were abundantly exposed. The name of the formation is derived from this locality.

The Camillus beds are generally barren of fossils though one or more of the thin dolomites in the upper part contain at some localities the crustacean Leperditia scalaris? Jones, and one or two other obscure forms.

No exposures of this formation occur on these quadrangles but the gypsum is mined at Oakfield and Alabama, and the upper part of the formation outcrops in the banks of Tonawanda creek below Indian Falls, on the quadrangles next north of these.

BERTIE WATERLIME

In the upper part of the Camillus beds there is an alternation of shales and limestones in which the shales lose much of their gypsum and the limestones become more compact and heavier and also, by the increased proportion of magnesia carbonate, highly dolomitic. These passage beds are succeeded by about 50 feet of waterlime, dark colored when fresh but weathering to a light gray, in layers from a few inches to 3 or 4 feet thick, separated by thin seams of black carbonaceous matter. The rock in some of the layers is quite compact and the lines of deposition are barely discernible, while other layers have a laminated structure or, in small proportion to the entire mass, are more or less shaly.

Digitized by Google

The proportion of calcareous and argillaceous matter varies considerably in different layers, the composition of some of them being such as to make true hydraulic limestone or natural cement rock. A bed of this character at the top of the formation and about 6 feet thick has been quarried extensively at Buffalo, Williamsville and Akron for the production of natural cement, and other layers were formerly utilized for this purpose in the central part of the State.

This formation receives its name from its favorable exposure in the township of Bertie, Ontario. It may be seen to excellent advantage at the falls of Ellicott creek in the village of Williamsville and there are frequent small exposures of the upper beds all along the lower part of the escarpment to Clarence and the large quarry two and one-half miles farther east.

Fossils are rare in the Bertie limestone here except the ostracod, Leperditia scalaris Jones, and the small brachiopod Whitfieldella laevis (Whitfield): these two occurring in considerable numbers in several thin layers and occasionally in the more compact and thicker layers. The stratum of cement rock at the top of the formation contains the remains of a peculiarly interesting arachnid or eurypterid fauna, which has recently been fully discussed and illustrated by Clarke and Ruedemann (N. Y. State Mus. Mem. 14, 1912). The wealth of this formation in these fossils has made it widely known and of great interest to paleontologists.

COBLESKILL WATERLIME

West of the Genesee river the Bertie waterline is succeeded by a few feet, not more than 6 to 8 on the Depew quadrangle, or dark subcrystalline dolomitic limestone in uneven layers, usually not more than a few inches thick, separated by thin seams of black carbonaceous matter. After exposure this rock sometimes has a brecciated appearance and is usually more or less porous owing to the removal by dissolution of crystals of calcite and of a small coral, Cyathophyllum hydraulicum Simpson, which occurs quite abundantly here and in the Buffalo quadrangle, but is very rare or absent from the Cobleskill in the central part of the State. The rock resembles the Bertie in being very dark when freshly quarried but weathering to a light gray or buff color. It is known to quarrymen as the "bull head" or "pumpkin head," and is of considerable economic value, being used largely in Buffalo for foundation walls and similar purposes.

Digitized by Google

Beside the coral mentioned the following fossils occur in the Cobleskill waterlimes in western New York:

Nematophyton crassum *Penhallow*
Favosites sp.
Orthothetes interstriatus (*Hall*)
Spirifer eriensis *Grabau*
Whitfieldella sulcata (*Vanuxem*)
W. nucleolata *Hall, var.*
W. *cf.* laevis (*Vanuxem*)
Rhynchonella *sp.*
Loxonema?
Pleurotomaria
Trochoceras gebhardi (*Hall*)

The Cobleskill waterlime is well exposed at Williamsville in the old quarries; in the village of Clarence, and at the larger quarry two and one half miles east of Clarence on the DeWitt quadrangle, and in the Buffalo cement quarry at Buffalo, at Akron, Fallkirk, Indian Falls and Morganville, North LeRoy, East Victor and Union Springs. It received its name on account of its fine exposure at Cobleskill in Schoharie county, and it may be seen in many other localities in eastern New York.

The Cobleskill waterlime is the highest formation belonging to the Siluric system in the rock section of New York west of Seneca lake, the Rondout waterlime and the Manlius limestone that succeed the Cobleskill in the central and eastern part of the State thinning out and disappearing east of that point.

In the large cement quarries at Buffalo and at nearly all exposures where the surface or cross sections of the contact with the succeeding formation can be observed, there are evidences of considerable erosion, the Paleodevonic strata resting more or less unconformably upon the Cobleskill.

DEVONIC

ORISKANY SANDSTONE HORIZON

Four Devonic formations, the Coeymans limestone, New Scotland beds, Becraft limestone and Port Ewen limestone, constituting the Helderbergian group in the eastern New York counties are absent in the western, the Oriskany sandstone being the lowest of the Devonic subdivisions known here.

This rock in its typical condition is composed of coarse white or pinkish quartz sand, loosely cemented by calcareous matter. It is not a continuous stratum on the line of its outcrops in central and western New York, but appears in cross sections of broad

Digitized by Google

lentils the largest of which are east of Cayuga lake and attain a thickness of 20 to 30 feet, and sometimes are quite fossiliferous.

There are exposures of thin lentils at Phelps, Honeoye Falls and Morganville and a vertical crevice in the Cobleskill waterlime in the cement quarry at Buffalo was filled with the characteristic gray sand of this formation, and at some localities where it is absent as a distinct stratum the basal tier of the succeeding limestone contains a considerable proportion of the same material.

At most exposures where the sand is not present this horizon is marked by a thin, uneven seam of black shaly matter, in which small pebbles of waterlime or black sand are imbedded forming a coarse conglomerate a few inches thick. The sandstone is absent and the horizon is but slightly marked on this quadrangle.

ONONDAGA LIMESTONE

This formation is composed of dark bluish gray limestone, bedded in layers from 3 inches to 2½ feet thick in which there is usually a quarter or less proportion of chert or hornstone in nodules or nodular layers. It was formerly known as the "Corniferous" limestone, and included in the "Upper Helderberg Group," a few layers at the base in which chert is absent being distinguished as the Onondaga limestone. The terms "Corniferous," and "Seneca" limestone were at one time used interchangeably. The term Onondaga limestone is now adopted to cover all the strata in central and western New York, which lie between the Oriskany horizon and the Marcellus black shale, here aggregating in thickness about 125 feet.

The limestone contains considerable black, carbonaceous matter that appears in the shaly partings and on the surface of the tiers. It is removed by slow decomposition on exposure and the rock weathers to a light bluish gray color.

The chert is usually very dark and but slightly translucent, but is sometimes much lighter colored and chalcedonic. It is very unevenly distributed in the beds predominating in some parts and frequently occurs in nodular layers that are continuous for long distances and the separate nodules from 1 to 3 inches in diameter occupy much of the remaining space.

Weathered outcrops and loose blocks from the cherty beds have a peculiarly ragged and scraggy appearance owing to the superior resistance to decomposition of the chert over the limestone. This chert, commonly called flint, was of the greatest value to our Indian predecessors as it is the material from which their spears, arrows and other implements were formed, but until recently its presence

Digitized by Google

has been regarded as seriously lessening the value of the limestone. Now, however, this rock is recognized as of great economic importance as constituting the best material, when crushed, for concrete work and road-building to be found in western New York and it is being extensively utilized for such purposes. At some outcrops one or more of the layers may be somewhat shaly, but all the remainder is compact and durable and is the source from which have been derived enormous quantities of dimension and building stone of the best quality as well as the purest quicklime.

At the base of the formation there occurs here 6 to 8 feet of limestone entirely free from chert. This condition is found at nearly all exposures of this horizon, the thickness in a few instances increasing to 25 or more feet. The rock is usually crowded with corals and crinoid stems, and is specially valued for ornamental building stone; it is also valuable as a flux in the manufacture of steel and is extensively quarried for such use. In the succeeding 40 or 50 feet the percentage of silicon is very high, reaching 50 per cent in some localities, while in some of the upper beds it is not more than 10 to 12 per cent.

This formation is rich in fossils. A list of the various species that occur in it may be seen in New York State Museum Bulletin 63, in which there are 3 of fishes, 39 of crustaceans, mostly trilobites, 13 of cephalopods, 3 pteropods, 38 gastropods, 15 lamellibranchs and 48 brachiopods. It also contains many species of corals and crinoids.

A few of the more common and distinguishing forms are:

Odontocephalus selenurus *Eaton*
Phacops cristata *var.* pipa *Hall and Clarke*
Gyroceras undulatum (*Vanuxem*)
Gyroceras trivolve (*Conrad*)

and the brachiopods

Atrypa reticularis *Linné*
Leptaena rhomboidalis *Wilckens*
Stropheodonta concava *Hall*
S. inequistriata (*Conrad*)
Spirifer acuminatus (*Conrad*)
Sp. divaricatus *Hall*

Exposures. The Onondaga limestone is covered by drift in most of the area in the northern part of the Attica quadrangle, where it is the surface rock. The largest outcrop is in the vicinity of an old quarry 2 miles north of Crittenden near the road to Murray where 12 to 15 feet of the upper layers are well displayed.

Digitized by Google

The lower beds are well exposed along the escarpment from the large quarry 2 miles northeast of Clarence to Williamsville and specially in both of those villages. The middle beds may be seen along Ellicott creek at Bowmansville and in some field outcrops and small quarries 2 miles north of Mill Grove, and the upper strata in the bed of Ellicott creek for a mile or two west of Mill Grove. At Bellevue what appear to be the uppermost layers of the Onondaga limestone are exposed in the bed of Cayuga creek north of the electric car line for 50 to 60 rods. The rock has been quarried here and the exposure includes about 10 feet. There is also a small outcrop of these strata in the south bank of the stream a mile northeast.

MARCELLUS BLACK SHALE

This term has been generally applied to a series of black and dark shales that immediately succeed the Onondaga and at the top pass gradually into the lighter colored Hamilton shales. At Marcellus, Onondaga county, from which locality the name is derived, only the lower beds are well exposed and recent observations in that region and in the western part of the State indicate the desirability of restricting the term to the lower shales exposed at the type locality.

Westward from Ontario county the Marcellus shale is clearly delimited on the top by the Stafford limestone, the shale above which, though very dark, is more calcareous and weathers to a light gray, while the rock between the Onondaga and the Stafford is a densely black and bituminous slaty shale with a few thin calcareous layers and, at some localities, a row of spherical concretions usually one to two feet in diameter.

On these quadrangles the Marcellus is 20 to 25 feet thick.

Fossils are common in the Marcellus shale at the base and for 3 or 4 feet at the top. Where this formation is more calcareous and lighter colored they are fairly abundant. A list numbering 20 species of those occurring in these beds at Lancaster may be found in New York State Museum Bulletin 49.

The following are the more abundant forms:

Ambocoelia nana *Grabau*
Chonetes mucronatus *Hall*
Isochilina? fabacea *Jones*
Liorhynchus limitare (*Vanuxem*)
Pterochaenia fragilis (*Hall*)
Nuculites triqueter *Conrad*
Orthoceras subulatum *Hall*
Strophalosia truncata (*Hall*)
Styliolina fissurella *Hall*

Digitized by Google

Exposures. A few inches of Marcellus black shale appear beneath the ledge of the Stafford limestone in the bed of Ellicott creek at Wende, south of the Lehigh Valley Railroad bridge. About 2 feet of black shale are exposed in Cayuga creek at Lancaster, just above the lower bridge, and also under the limestone below the Lake Como dam and similarly situated, in the bed of Plumb Bottom creek east of Foundry street. No other outcrops of the Marcellus shale occur on these quadrangles.

STAFFORD LIMESTONE

In western New York the Marcellus black shale is overlaid by a bluish gray compact limestone, that at its most eastern exposure on Flint creek in the town of Phelps, Ontario county, is but 4 inches thick but increases to 3 feet at Stafford, 8 feet 4 inches at Lancaster and, according to a well record, to 15 feet on Smoke creek in West Seneca. In the Seneca Lake valley this horizon is marked by a band of gray calcareous shale in which are imbedded spheric concretions containing fossils of the same species as those found in the limestone on these quadrangles. The largest exposure of this formation and the one most favorably situated for examination is in the beds of Cayuga and Plumb Bottom creeks in the village of Lancaster, where all the strata may be seen. It is here composed of 6 to 8 layers of limestone varying but slightly in lithologic character and quite fossiliferous throughout.

The Stafford limestone at Lancaster and its fauna have been fully described in New York State Museum Bulletin 49, with a complete list of the fossils and descriptions of species, of which there are 72. The more common forms are:

Ambocoelia nana *Grabau*
Chonetes mucronatus *Hall*
C. scitulus *Hall*
Liorhynchus limitare (*Vanuxem*)
Strophalosia truncata (*Hall*)
Meristella barrisi *Hall*
Spirifer subumbonatus *Hall*
Cypricardinia indenta *Conrad*
Orthoceras exile *Hall*
O. marcellense *Vanuxem*
Phacops rana *Green*
Primitiopsis punctulifera *Hall*

Exposures. Besides those mentioned as occurring at Lancaster, a small outcrop in the bed of Ellicott south of the Lehigh Valley Railroad bridge, and a very small one in an old pit 2 miles north of Alden, there is no exposure of Stafford limestone on these

Digitized by Google

quadrangles. There is a quite extensive field exposure at Stafford, from which village the name is taken, and the limestone appears in the cliff below Main street bridge in LeRoy, and also below the mill at Ashantee, near Avon.

CARDIFF SHALE

The upper beds usually included in the old term Marcellus and designated by Vanuxem the "Upper shales of Marcellus," are abundantly exposed near Cardiff, Onondaga county, and have been named from that locality (New York State Museum Bulletin 63, page 16).

The Cardiff shales decrease in thickness from the type locality westward to about 50 feet here, and also become much darker and more bituminous. On these quadrangles they vary but little in character from the shales below the Stafford limestone, though on the whole a little more calcareous and, after exposure, lighter colored. At the top there is a stratum of impure limestone 12 to 15 inches thick, quite hard but somewhat shaly in old exposures. The shales at the base and the limestone near the top of the formation are moderately fossiliferous, but the intervening beds are usually not rich in fossils.

The following forms have been reported from the calcareous lower shales overlying the Stafford limestone at Lancaster:

Ceratopora dichotoma *Grabau*
Chonetes lepidus *Hall*
Liorhynchus limitare (*Vanuxem*)
Atrypa reticularis *Linné*
Ambocoelia umbonata (*Conrad*)
Meristella barrisi *Hall*
Pterochaenia fragilis (*Hall*)
Styliolina fissurella *Hall*
Orthoceras aegea *Hall*
Phacops rana *Green*

Tornoceras uniangulare and Orbiculoidea minuta are common in these beds in Livingston and Ontario counties but are very rare here.

The only exposures of the Cardiff beds on these quadrangles are on Cayuga and Plumb Bottom creeks in Lancaster, where 2 or 3 feet of the lower shale succeeds the Stafford limestone, and at the junction of Cayuga and Little Buffalo creeks one-half mile east of Lancaster, where the hard layer mentioned (which here contains fine specimens of Phacops rana) is exposed under the highway bridge. The shale next above this hard layer for 10 to 12 feet belongs to this formation.

Digitized by Google

HAMILTON BEDS

SKANEATELES SHALE

The term "Skaneateles shale" was applied by Vanuxem to the beds overlying the Marcellus (Cardiff) shale and exposed on both sides of the north end of Skaneateles lake. It subsequently fell into disuse, but when the State Survey found itself compelled to adopt a more exact and refined classification of the strata than that hitherto in use, the term Skaneateles shale was re-applied in its original meaning and scope. It is the lowest division of the Hamilton beds, and on these quadrangles has an estimated thickness of 40 to 50 feet.

The passage from the Cardiff shale is a gradual one, there being but slight difference between the upper beds of that formation and the lower Skaneateles shales. They become lighter colored and more argillaceous in the upper part but the formation as a whole is much darker on these quadrangles than in the type locality.

The Skaneateles shale is delimited at the top by a calcareous band known as the Centerfield limestones. Fossils are common in the lower and more calcareous portion of the formation, but rare in the upper beds at most localities.

The following species have been reported as occurring in these beds on the Buffalo quadrangle:

Phacops rana *Green*
Cryphaeus boothi *Green*
Primitiopsis punctuliferus *Hall*
Orthoceras *sp.*
Tentaculites gracilistriatus *Hall*
Styliolina fissurella *Hall*
Euomphalus (Phanerotinus) laxus *Hall*
Bellerophon leda *Hall*
Pterochaenia fragilis (*Hall*)
Nuculites triqueter *Conrad*
Orthothetes arctostriatus *Hall*
Chonetes mucronatus *Hall*
C. setigerus (*Hall*)
C. scitulus *Hall*
C. lepidus *Hall*
Productella spinulicosta *Hall*
Strophalosia truncata (*Hall*)
Spirifer mucronatus *Conrad*
Ambocoelia umbonata (*Conrad*)
Liorhynchus limitare (*Vanuxem*)
Tropidoleptus carinatus (*Conrad*)
Crinoid stems.

Digitized by Google

Exposures. There are a few feet of Skaneateles shales uncovered below the limestones in the bed of Murder creek opposite the Losee schoolhouse one and one-fourth miles north of Darien, and also in the bed and banks of Crooked creek a mile west of the schoolhouse. The middle beds are exposed along Cayuga and Little Buffalo creeks 1 to 2 miles south and east of East Lancaster and also along Buffalo creek west of Blossom. The upper beds and the contact with the succeeding formation are displayed below the dam at Blossom.

LUDLOWVILLE SHALE

This formation embraces about 100 feet of soft, light colored shales in which there are interbedded many calcareous concretions and concretionary layers, and, near the base, a continuous band of thin limestones. It is capped by a stratum of encrinal limestone that is continuous from Madison county to Lake Erie.

The term Ludowville shale was adopted by Hall on account of the exposure of these beds at Ludlowville, on Cayuga lake. The calcareous band near the base was described in New York State Museum Bulletin 63 and designated the Centerfield limestone from its favorable exposure in the bed of Shaffer creek at Centerfield in Ontario county. It appears at all exposures of its horizon from that locality westward to Lake Erie varying but little in character except as to the relative thickness of the thin layers of hard limestone of which the band is composed. It is usually succeeded by a soft shale containing a great abundance of corals. At Centerfield and in the Delaware, Lackawanna & Western Railroad cuts 2 miles west of East Bethany, the exposures indicate coral reefs of considerable extent. This limestone resembles somewhat the Tichenor limestone that succeeds the Ludlowville shale and at isolated exposures has been mistaken for it. It is not represented in the coloring on the map but its position is shown by the north line of the Ludlowville area.

The beds in the middle part of the Ludlowville are not usually very fossiliferous, but the upper shales are richer and the concretionary layers contain many finely preserved specimens. The lower limestone at Centerfield afforded 92 species and Doctor Grabau's list of Ludlowville fossils from Eighteen Mile creek and vicinity names 120 species, embracing 6 crustaceans, 4 cephalopods, 4

Digitized by Google

pteropods, 29 lamellibranchs, 50 brachiopods, 1 crinoid, 8 bryozoans and 7 anthozoans. The common forms are:

Phacops rana *Green*
Cryphaeus boothi *Green*
Proetus rowi *Green*
Platyceras auriculatum *Hall*
P. thetis *Hall*
Nautilus magister *Hall*
Orthoceras nuntium *Hall*
Styliolina fissurella *Hall*
Diaphorostoma lineatum *Hall*
Pterinea flabellum *Conrad*
Actinopteria decussata *Hall*
Modiomorpha subalata *Conrad*
Palaeoneilo tenuistriata *Hall*
Stropheodonta demissa (*Conrad*)
Leptostrophia perplana (*Conrad*)
Rhipdomella vanuxemi *Hall*
Orthothetes arctostriatus *Hall*
Chonetes lepidus *Hall*
C. scitulus *Hall*
Spirifer mucronatus (*Conrad*)
Sp. granulosus (*Conrad*)
Sp. fimbriatus *Hall*
Sp. subumbona *Hall*
Ambocoelia umbonata (*Conrad*)
Athyris spiriferoides (*Eaton*)
Atrypa spinosa *Hall*
Camarotoechia dotis *Hall*
Tropidoleptus carinatus (*Conrad*)
Liorhynchus multicostum *Hall*
Pleurodictyum stylopora (*Eaton*)
Streptelasma rectum *Hall*

Exposures. There are many fine exposures of the Ludlowville shales on these quadrangles. The upper beds outcrop along Bowen brook and the entire section or nearly all of it along Murder creek north of Darien; along Ellicott creek one and three-fourths miles west of Darien Center, and along Spring creek and the Erie Railroad east of Alden. The middle beds are displayed in the bed of Cayuga creek a mile south and southeast from Marilla Station. At the fall in Buffalo creek at the Bullis bridge, 2 miles west of Marilla, the exposure of the upper beds and the contact with the Tichenor limestone is exceptionally large and favorable for the collection of fossils, and the middle and lower shales are displayed along the bed and banks of the stream to Elma and Blossom. The

Digitized by Google

upper beds with the overlying limestone are well exposed in the bed of Cazenovia creek below the bridge at Spring Brook.

TICHENOR LIMESTONE

The stratum of limestone that succeeds the Ludlowville shale has been commonly known as the "Encrinal limestone," a name applied to it by Hall in 1839 on account of the great abundance of fragments of crinoid stems contained in it.

Since this term has been applied by others to limestone layers of similar character occurring at distinctively different horizons and specially to the limestones in the lower Ludlowville beds, thereby causing confusion in the identification of horizons, a more distinctive appellation for this stratum was required. It has therefore been designated Tichenor limestone from its typical exposure in the ravine at Tichenor point on Canandaigua lake and along the shore toward the south. It usually consists of a single compact layer of bluish gray limestone, hard and durable, with a thickness varying from 12 to 18 inches and continuous, with many outcrops, from Onondaga county to Lake Erie, disappearing at the mouth of Pike creek.

This stratum in central New York is usually overlaid by calcareous shales, but on these quadrangles where the formation attains its greatest development on the line of outcrop it is followed by one or more layers of limestone that make the total thickness of the formation about 3 feet. The Tichenor limestone carries an abundant fauna. Doctor Grabau's list contains the names of 60 species occurring in it in this region, of which the following are the more abundant and striking forms:

Phacops rana *Green*
Diaphorostoma lineatum *Hall*
Modiomorpha concentrica *Conrad*
Rhipdomella vanuxemi *Hall*
R. penelope *Hall*
Spirifer granulosus (*Conrad*)
Sp. mucronatus *Hall*
Vitulina pustulosa *Hall*
Centronella impressa *Hall*
Cryptonella planirostra *Hall*
Tropidoleptus carinatus (*Conrad*)
Favosites hamiltoniae *Hall*

Exposures. The Tichenor limestone is exposed in the lower part of most of the principal ravines in the southern part of this quadrangle, and by reason of its superior resistance to the erosive power

Digitized by Google

of the stream, cascades have been produced with the limestone at the crests and long exposures in the banks farther down the stream. The larger and more accessible of these exposures are: on Bowen creek 2 miles northwest of Alexander; on Murder creek 30 rods below the bridge at Darien; on Ellicott creek one and three-fourths miles west of Darien Center; at west end of Erie Railroad cut 2 miles east of Alden; in the bed of Durkee creek at 900 A.T. and in the bed of a small stream flowing into Cayuga creek 2 miles south of West Alden. At the Bullis bridge over Buffalo creek the Tichenor limestone is the crest of the fall, and is bare to the extent of half an acre above. It is displayed in the cliffs below the fall for one-quarter of a mile and the bed of the stream is strewn with large blocks from it. The Ludlowville and Moscow shales are also finely exposed, making this an exceedingly interesting as well as picturesque locality.

The limestone is well exposed in the bed of Cazenovia creek below the bridge at Spring Brook and also at the crest of a cascade in a small branch of Cazenovia creek, near the west line of the quadrangle 2 miles north of Webster Corners.

MOSCOW SHALE

This formation rests on the Tichenor limestone and consists in these quadrangles of about 50 feet of soft, light bluish gray shales that are usually somewhat calcareous and embrace several courses of flat concretions. The latter become at some exposures continuous concretionary layers crowded with fossils. Eastward from Ontario to Chenango counties the light colored Moscow is separated from the black Genesee shale by the Tully limestone, but west of Canandaigua lake and on these quadrangles this limestone and the Moscow beds are directly followed by thin lentils of iron pyrite or black shale.

Like most of the Devonic formations, the Moscow diminishes in thickness toward the west. At Moscow in the Genesee River valley, the locality from which the term Moscow shale is derived, the beds are 130 feet thick and on the south side of the mouth of Eighteen Mile creek at North Evans they measure but 17 feet.

Moscow shale is everywhere exceedingly rich in fossils, but the specimens are, as a rule, not so well preserved as in the Ludlowville shale, and there is little difference between the faunas of the Moscow and Ludlowville shale. Doctor Grabau reported 51 species from the Moscow beds in the Eighteen Mile creek region, the following being the more common forms:

Digitized by Google

Phacops rana *Green*
Tentaculites gracilistriatus *Hall*
Palaeoneilo tenuistriata *Hall*
Pholidops hamiltoniae *Hall*
Spirifer tullius *Hall*
Sp. consobrinus *d'Orbigny*
Chontes deflectus *Hall*
C. mucronatus *Hall*
Leptostrophia perplana (*Conrad*)
Ambocoelia umbonata (*Conrad*)
Atrypa reticularis *Linné*
A. spinosa *Hall*
Streptelasma rectum *Hall*
Cystiphyllum conifollis *Hall*

Exposures. The Moscow beds are advantageously exposed along Bowen brook 2 miles northwest of Alexander; along Murder creek between Griswold and Darien; in the bed of Ellicott creek from the fall one and three-fourths miles west of Darien Center to a low cascade 35 rods below the Erie Railroad bridge; in the Erie Railroad cut 2 miles east of Alden; in a ravine 2 miles southeast of West Alden; 6 feet of upper beds on Little Buffalo creek half a mile below Marilla; and especially fine and conveniently accesssible exposures are in the Buffalo Creek gorge above the falls at the Bullis bridge 2 miles west of Marilla; in the Cazenovia Creek gorge at Spring Brook and in a small ravine 2 miles north of Websters Corners.

TULLY HORIZON — PYRITE LENSES

The Tully limestone that succeeds the Moscow shale in central New York and is 30 feet thick in Onondaga county, thins out toward the west to Ontario county and is not known west of Canandaigua lake. In its place there appear at frequent intervals along the line of outcrop of this horizon, thin lenticular masses or lentils composed almost entirely of iron pyrites. These lentils in a few instances attain a thickness of 4 to 5 inches, but are usually less than 2, and they vary greatly in breadth, ranging from a few feet to the entire length of exposure many rods long.

Fossils are quite common in the pyrite and are mostly of species common in the Moscow or Genesee shales, but greatly reduced in size. A list prepared by Dr F. B. Loomis, published in New York State Museum Bulletin 69, contains the names of 48 species collected from the pyrite in this horizon in Ontario and Livingston counties. Most of these are pigmy forms of well-known species reduced to about one-fifteenth of their normal size. The more abundant forms are:

Digitized by Google

Spirifer mucronatus *mut.* hecate *Clarke*
" fimbriatus *mut.* pygmaeus *Loomis*
" granulosus *mut.* pluto *Clarke*
Ambocoelia umbonata *mut.* pygmaeus *Loomis*
Paracyclas lirata *mut.* pygmaeus *Loomis*
Tornoceras uniangulare *Conrad*
Orthoceras subulatum *mut.* pygmaea *Loomis*
Pleurotomaria, 3 species
Crinoid stems

Exposures. A thin lentil occurs in a small ravine half a mile west of Alexander and a similar one in the east bank of Murder creek 40 rods north of the railroad station at Griswold. A 1 inch lentil appears in the east bank of Ellicott creek one and one-half miles west of Darien Center, and at the iron bridge over Cayuga creek one and one-half miles below Cowlesville, a lentil of more than ordinary thickness and breadth is finely exposed. Another 2 inches thick, is in the banks of Little Buffalo creek half a mile below Marilla. There are traces of lentils in the long exposure of this horizon in the banks of Cazenovia creek south of Spring Brook, but they are all very thin.

GENESEE BLACK SHALE

The heavy beds of black and dark slaty shale that succeed the light colored Moscow shale in Ontario and Livingston counties were, in Hall's original classification, all included under the term Genesee shale, from their exposure in the Genesee river valley. Subsequent investigations disclosed such differences in the character of these beds as to require, in the interest of clearness and accuracy of description, a division into four distinct members or formations, the lowest of which in the type locality is 90 feet thick and capped by a bed of light gray limestone. The shale composing this member is nearly all densely black and slaty answering to the original description of the Genesee slate, and the use of that term is now restricted to these beds. It thins out from the type locality rapidly toward the west to about 20 feet on the east line of these quadrangles and to less than 2 feet on the western boundary.

Fossils are not usually abundant in the Genesee, but Chonetes setigera occurs in great numbers in the upper part at the exposure in Ellicott creek west of Darien Center and at the iron bridge north of Cowlesville. Styliolina fissurella is also common, and Pterochaenia fragilis and small cephalopods occur occasionally.

Digitized by Google

Exposures. This black shale is exposed in the ravine west of Alexander; above and below the railroad bridge at Griswold; below the railroad bridge a mile west of the station at Darien Center, and at a 5 foot fall in Durkee creek, 3 miles southeast from Alden, where the entire section with an interbedded row of spherical concretions and the overlying limestone are displayed. It is 8 feet 6 inches thick at the fine exposure under the Iron bridge northwest of Cowlesville; 7 feet in the bed of Buffalo creek below Marilla, 3 feet 6 inches in a long exposure in the gorge of Cazenovia creek south of Spring Brook.

GENUNDEWA LIMESTONE

From Canandaigua lake westward to Lake Erie the black Genesee shale is succeeded by a limestone formation consisting at Genundewa point on Canandaigua lake, of several thin layers of limestone and calcareous shale. The layers of limestone decrease in number toward the west, but as the remaining ones retain their peculiar characteristics the formation is easily recognized and is a convenient stratigraphic bench mark. On these quadrangles it consists of a concretionary layer 8 to 10 inches thick overlaid by 3 to 6 inches of limestone, slightly shaly and composed, in large proportion, of the minute shells of a pteropod, Styliolina fissurella. This characteristic is persistent, and the formation has been sometimes referred to as the "Styliola limestone" for this reason. Most of the exposures of the Genundewa limestone are in the bottom of ravines where, by its superior hardness over the shales beneath and above, small falls or cascades are produced. It is exposed in both branches of the ravine half a mile west of Alexander; in the bed of Murder creek on the south side of the Erie Railroad bridge at Griswold; in the bed of Ellicott creek 1 mile west of Darien Center; above the falls in Durkee creek southwest of Alden; under the iron bridge northwest of Cowlesville, and in a small ravine half a mile north of the bridge; finely in the bed of Buffalo creek at Marilla; in the banks of the Buffalo Creek gorge south of the Bullis bridge and in the Cazenovia Creek gorge south of Spring Brook. It dips beneath the water level of Lake Erie a mile southwest of Pike creek. The fauna of the Genundewa limestone in Ontario and Livingston counties comprised 44 species and is of peculiar interest in that the brachiopods and corals so abundant in the Ludlowville and Moscow calcareous layers and shales are absent here, and the fossils are mostly species of cepha-

Digitized by Google

lopods, gastropods and lamellibranchs that make their earliest appearance in this limestone.

The fauna includes the following species:

Manticoceras pattersoni *Hall*
Gephyroceras genundewa *Clarke*
Tornoceras uniangulare (*Conrad*)
Orthoceras atreus *Hall*
Styliolina fissurella *Hall*
Pleurotomaria genundewa *Clarke*
Bellerophon koeneni *Clarke*
Phragmostoma natator *Hall*
Loxonema noe *Clarke*
Pterochaenia fragilis (*Hall*)
Honeoyea styliophila *Clarke*
Ontaria suborbicularis *Hall*
Buchiolia retrostriata (*von Buch*)
Paracardium doris *Hall*
Melocrinus clarkei *Williams*
Plant remains and fish remains also occur.

WEST RIVER SHALE

The beds of dark shale that succeed the Genundewa limestone in the Genesee valley to the thickness of about 100 feet were until recently known as the upper Genesee shales. In that locality about 65 feet next above the limestone were dark bluish gray shales with thin layers of black shale interbedded at intervals of 3 to 8 feet. The term West River shale is now used to designate these beds on account of their abundant exposure in the West River valley in the western part of Yates county, the remaining 35 feet of the Upper Genesee beds receiving the name Middlesex black shale.

The thickness of the West River shale is decreased to 30 feet on the east line of these quadrangles and to 15 feet on the west boundary, but the character of the rock is not altered, spherical concretions and occasionally a thin calcareous sandstone flag appearing in the shales at nearly all exposures.

Fossils. The fauna of the West River shale embraces the following species, nearly all from the lighter colored shales:

Bactrites aciculum *Hall*
Gephyroceras *sp.*
Pleurotomaria rugulata *Hall*
Buchiola retrostriata (*von Buch*)
Panenka *sp.*
Pterochaenia fragilis *Hall*
Lunulicardium curtum *Hall*
Lingula spatulata *Vanuxem*
Orbiculoidea
Melocrinus clarkei *Williams*

Digitized by Google

Exposures. The West River shale outcrops in the banks of the ravines west of Alexander, and along Tannery creek at Attica to the little falls below the second highway bridge; at Griswold 25 rods south of the Erie Railroad in the west bank of Murder creek; along Ellicott creek below the railroad west of Darien Center; at the falls in Durkee creek southeast of Alden; in the west bank of Cayuga creek at the Iron bridge and in the small ravine half a mile north; also along Little Buffalo creek below Marilla; in the banks of the Buffalo Creek gorge one-half mile south of the Bullis bridge, and in the gorge of Cazenovia creek one and one-half miles south of Spring Brook.

MIDDLESEX BLACK SHALE

A band of black slaty shales about 20 feet in thickness succeeds the West River beds and is followed by argillaceous shales of a much lighter color. This band was formerly considered as a part of the upper Genesee shales, but differs from the beds below it not only in respect to its lithologic character, but also in its fauna, the characteristic fossils of the West River beds being absent from these.

In United States Geological Survey Bulletin 16, 1885, Clarke separated this black shale from the Genesee, and considered it under the term "Lower Blank Band of the Portage Group." In New York State Museum Bulletin 63 it received the designation Middlesex black shale on account of its abundant exposure in the Middlesex valley in Yates county, from which locality it is continuous westward without change of character, though diminishing gradually in thickness to about 6 feet at the point where it dips under the water of Lake Erie, in the town of Evans in Erie county. It is nearly barren of fossils except lignites. A small lingula, L. ligea, occurs in this horizon near the mouth of Pike creek.

Exposures. At the cascade on Tannery brook one-half mile northwest of Attica; on Murder creek 30 rods south of the railroad bridge at Griswold; near the Erie Railroad bridge over Ellicott creek; along Durkee creek; Little Buffalo creek at Marilla; Buffalo creek one mile below East Elma and along Cazenovia creek one and one-half miles south of Spring Brook.

CASHAQUA SHALE

This formation is composed of light bluish or olive clayey shales having an aggregate thickness on the east line of these quadrangles of about 80 feet, decreasing to 50 feet on the west line. Calcareous

Digitized by Google

concretions are common in the shale and blocky calcareous layers 2 to 5 inches thick occur at intervals of from 1 to 5 feet and a few thin flags also appear at some outcrops. The passage from dark to light shale at the bottom and from light to dark at the top is in both cases gradual through several alternations in 5 to 10 feet, but the formation presents an aspect so different from the beds above and below as to make recognition easy.

It was described and considered as the lowest member of the Portage group by Prof. James Hall in the Report on the Geology of the Fourth District, 1840, and by him designated the Cashaqua shale on account of its specially fine exposure along Cashaqua creek in Livingston county. The Cashaqua beds are 165 feet thick in the Genesee River gorge and but 32 feet in the cliffs on the shore of Lake Erie.

Fossils are not found in great abundance in these beds, but are fairly common in some of the upper shales, and some of the large flat concretions in the upper part of the formation contain finely preserved goniatites and orthoceratites.

The following are the more common and characteristic species of the Cashaqua shale:

Manticoceras pattersoni *Hall*
Probeloceras lutheri *Clarke*
Tornoceras uniangulare (*Conrad*)
Bactrites aciculum *Hall*
Orthoceras pacator *Hall*
O. ontario *Clarke*
O. filosum *Clarke*
Phragmostoma natator *Hall*
Lunulicardium (Pinnopsis) acutirostrum *Hall*
L. (Pinnopsis) ornatum *Hall*
Pterochaenia fragilis *Hall*
P. cashaqua *Clarke*
Honeoyea major *Clarke*
Ontaria suborbicularis *Hall*
O. accincta *Clarke*
Buchiola retrostriata (*von Buch*)
Paracardium doris *Hall*
Paleoneilo petila *Clarke*
Lingula ligea *Hall*
Aulopora annectens *Clarke*
Melocrinus clarkei *Williams*

Exposures. There are good exposures of the Cashaqua beds in both branches of Tannery brook a mile west of Attica. In the Murder Creek ravine at Griswold the entire section may be seen to excellent advantage. The upper beds are well shown below the

Digitized by Google

milldam at Cowlesville, and below the bridge over Buffalo creek at East Elma, and the entire section in the bed and sides of Cazenovia creek for more than a mile. There are also many outcrops in small ravines and roadside gutters.

RHINESTREET BLACK SHALE

This formation, consisting of a heavy mass of black shale succeeding the light colored Cashaqua beds, is 90 to 100 feet thick on the east line of these quadrangles and 150 feet on the west. With one exception, the Dunkirk black shale, higher in the series, it is the only Devonic formation that decreases in thickness toward the east. It extends as far as the Keuka Lake valley on the east, where outcrops show but 6 to 10 feet of the black shale, and to the shore of Lake Erie in the town of Evans, where it is 185 feet thick. On these quadrangles it includes a few thin bands of dark bluish gray shale usually from 3 to 5 feet thick that contain large symmetric concretions and septaria, some of which attain a diameter of 3 to 6 feet.

The black shales are quite barren of fossils, except plant remains, fish remains and conodont teeth, all of which are very rare. In the lighter shales obscure forms like those found in the Cashaqua shales occur but are also rare.

Exposures. Rhinestreet shale is the surface rock over a large area and is exposed in numerous ravines, frequently at and above cascades produced by its greater resistance to the erosive power of the streams than the more argillaceous Cashaqua shale. The larger exposures are along Tonawanda creek at Sierks; in the Tannery Brook ravines; in the upper part of Murder Creek ravine, along Cayuga creek at Folsomdale, Buffalo creek at Porterville and along Cazenovia creek at Jewettville and the banks of the gorge for 3 miles below.

HATCH SHALES AND FLAGS

In the Genesee River Gorge section the Rhinestreet shale is succeeded by about 150 feet of dark ferruginous and light blue shales with frequent layers of thin sandstone and overlaid by a well-defined sandstone. The black Rhinestreet shale and these beds were included by Professor Hall in the Report on the Geology of the Fourth District, 1842, in the formation designated "Gardeau flags and shales," but for reasons set forth in New York State Museum Bulletins 63 and 118 they were separated and considered as units in the Portage series and designated "Hatch flags and shales" from their exposure at the base of Hatch hill at the head of the

Digitized by Google

Canandaigua Lake valley. In Ontario and Livingston counties they are succeeded by a band of compact sandstone designated the Grimes sandstone.

The beds become softer toward the west and lighter colored, though black bands are frequent. Large flat concretions are common in the lower part and there are a few flags. Iron pyrite in nodules and small nodular masses is quite common in both shales and sandstones at some localities. Fossils are somewhat rare in this member of the series, but occur quite frequently in the lower beds and become more common toward the west.

The larger concretions mentioned contain very fine goniatites and other species along the Lake Erie shore. The fauna includes:

Manticoceras rhynchostoma *Clarke*
M. oxy *Clarke*
M. sororium *Clarke*
M. pattersoni *Hall*
Tornoceras uniangulare (*Conrad*)
Bactrites aciculum *Hall*
Ontaria suborbicularis *Hall*
Buchiola retrostriata (*von Buch*)
Paracardium doris *Hall*
Pterochaenia fragilis (*Hall*)
Cladochonus *sp.*
Lignites and fucoids also occur.

Exposures. Along Crow creek above the reservoir 2½ miles southeast of Attica; in Tannery brook below Danley Corners; in the ravine of the Right branch of Cayuga creek below Bennington, and along Hunters creek a mile southwest of Wales Center, and along the road leading west from Jewettville.

GARDEAU FLAGS AND SHALES

As set forth in New York State Museum Bulletin 118, this term is now used to designate the strata resting upon the Grimes sandstone in Livingston and Ontario counties and succeeded by the Nunda sandstones. The Grimes sandstones thin out westwardly and have not been traced to these quadrangles with certainty, but an arenaceous band consisting of two or three sandstones 12 to 18 inches thick that appears to be at or near the Grimes horizon marks a change in the sedimentation and is here considered the base of the Gardeau beds.

This formation is composed of sandstones, thin flags, hard sandy shales, soft clayey shales and in the lower part a considerable proportion of dark to black shale that increases toward the west and large calcareous concretions occur in all parts. A bed of black

Digitized by Google

shale near the base, much heavier on the shore of Lake Erie, has been designated the "Dunkirk black shale." The aggregate thickness of the Gardeau beds on these quadrangles is approximately 300 feet.

Fossils are very rare in most of the strata, except some of the light colored soft shales, where they are fairly common. The fauna is composed of the following species:

Manticoceras rhynchostoma *Clarke*
M. pattersoni *Hall*
M. oxy *Clarke*
Tornoceras uniangulare *Conrad*
Orthoceras pacator *Hall*
Bactrites aciculum *Hall*
Styliolina fissurella *Hall*
Phragmostoma natator *Hall*
Loxonema multiplicatum *Clarke*
Palaeotrochus praecursor *Clarke*
Lunulicardium bickense *Holzapfel*
Honeoyea erinacea *Clarke*
H. major *Clarke*
H. desmata *Clarke*
Posidonia attica *Williams*
Ontaria suborbicularis *Hall*
O. clarkei (*Beushausen*)
Euthydesma subtextile *Hall*
Buchiola retrostriata *von Buch*
B. lupina *Clarke*
Paracardium doris *Hall*
Pterochaenia fragilis *Hall*
Hydnoceras nodosum *Hall*
Cladochonus *sp.*
Lignites.

Exposures. Exposures of the Gardeau flags and shales are in all the ravines on the west side of the Tonawanda Creek valley, and specially good ones are in the large ravine above the railroad west of Varysburg, and in the large Stony Brook ravine east of that village. The flags and heavier sandstones crop out in many of the small gullies in the towns of Bennington and Sheldon and those in the southern part of Attica.

NUNDA SANDSTONES

Toward the west from the Genesee River gorge at Portageville where this formation is a nearly homogeneous mass of compact light bluish gray sandstone nearly 200 feet thick, it gradually becomes softer and more shaly. This tendency appears to be stronger in the lower portion, reducing the thickness of the strata retaining

Digitized by Google

the characteristics of the sandstones at the type locality to 125 to 150 feet on these quadrangles and of these some are less compact.

Fossils (except lignites) are rarely found in the sandstones and there are very few in the shaly partings. The following forms, collected at Portageville, constitute the fauna of the Nunda sandstones in this region:

Manticoceras oxy *Clarke*
M. rhynchostoma *Clarke*
Orbiculoidea *sp.*
Cladochonus *sp.*
Crinoid stems
Fucoids

Exposures. The Nunda beds are well exposed in but two localities on these quadrangles. The entire section may be seen in the bed and sides of the upper part of a ravine in the hillside west of Varysburg, and at the highway bridge over the Stony Brook gorge 2 miles east of Varysburg. There are small outcrops near South Attica, also on Poland hill and west of Persons Corners.

WISCOY SHALES

This formation, named from its exposure at the falls of West Coy creek at Wiscoy in the Genesee River valley, is composed at the type locality of a band of black shale 20 feet thick at the base, succeeded by 150 to 170 feet of light soft shale resembling the Cashaqua beds, with thin bands of black shale and a few thin layers of hard and soft sandstones. Calcareous concretions are common at some horizons.

The formation is capped by a band of hard, calcareous sandstones, containing brachiopods, that produces in the bed of the Genesee river a small cascade known as Long Beards riffs. These beds were formerly considered as belonging to the Chemung group, but their close resemblance lithologically and in the character of their fossils, to the Cashaqua beds, and the entire absence of the brachiopods that distinguish the Chemung rocks, have been deemed sufficient grounds for their description as a separate formation.

Fossils. The following species occur at Wiscoy:

Manticoceras oxy *Clarke*
Orthoceras *sp.*
Pleurotomaria *sp.*
Hyolithes neapolis *Clarke*
Buchiola retrostriata (*von Buch*)

Digitized by Google

Lunulicardium (Pinnopsis) wiscoyense *Clarke*
Paracardium doris *Hall*
Lingula ligea *Hall*
Zaphrentis *sp.*

Exposures. The basal black band, 15 feet thick, is exposed in the upper part of the ravine west of Varysburg with a few feet of the lighter nodular shales above.

CHEMUNG SANDSTONE AND SHALES

Sandstones and shales of this division are the surface rocks over a small area on the hill west of Varysburg, but are not exposed on these quadrangles.

BIBLIOGRAPHY

The formations described in this bulletin are also described in the following publications of the New York State Museum:

Report on the Geology of the Fourth District. James Hall. 1842

Faunas of the Hamilton Group of Eighteen Mile Creek. A. W. Grabau. Sixteenth Report of the N. Y. State Geologist (for 1896)

Geology of Erie County. I. P. Bishop. Fifteenth Report of the N. Y. State Geologist (for 1895)

Geology of the Buffalo Quadrangle. N. Y. State Mus. Bul. 99

Canandaigua-Naples Quadrangles. Clarke & Luther. N. Y. State Mus. Bul. 63

Watkins-Elmira Quadrangles. Clarke & Luther. N. Y. State Mus. Bul. 81

Penn Yan-Hammondsport Quadrangles. Luther. N. Y. State Mus. Bul. 101

Nunda-Portage Quadrangles. Clarke & Luther. N. Y. State Mus. Bul. 118

Geneva-Ovid Quadrangles. Luther. N. Y. State Mus. Bul. 128

Auburn-Genoa Quadrangles. Luther. N. Y. State Mus. Bul. 137

Digitized by Google

INDEX

Actinopteria decussata, 17
Akron, 8, 9
Alabama, 7
Alden, 13, 17, 19, 20, 24
Alexander, 19, 20, 21, 22, 24
Ambocoelia **nana**, 12, 13
umbonata, 14, 15, 17, 20
mut. pygmaeus, 21
Ashantee, 14
Athyris spiriferoides, 17
Atrypa reticularis 11, 14, 20
spinosa, 17, 20
Attica, 24, 25, 27, 28
Aulopora annectens, 25
Avon, 14

Bactrites aciculum, 23, 25, 27, 28
Bellerophon koeneni, 23
leda, 15
Bellevue, 12
Bennington, 27, 28
Bertie waterlime, 6, 7–8; exposures, 8
Bibliography, 30
Bishop, I. P., cited, 30
Blossom, 16, 17
Bowen creek, 17, 19, 20
Bowmansville, 12
Buchiola lupina, 28
retrostriata, 23, 25, 27, 28, 29
Buffalo, 8, 9, 10
Buffalo creek, 16, 17, 19, 20, 22, 24, 26
Buffalo quadangle, 15
Bullis bridge, 17, 19, 20, 22, 24

Camarotoechia dotis, 17
Camillus, 7
Camillus shale, 6, 7
Canandaigua lake, 18, 20, 22
Cardiff, 14
Cardiff shale; 6, 14
Cashaqua creek, 25
Cashaqua shale, 6, 24–26; exposures, 25–26
Cayuga creek, 6, 12, 13, 14, 16, 17, 19, 21, 24, 26, 27
Cayuga lake, 10
Cazenovia creek, 6, 18, 19, 20, 21, 22, 24, 26
Centerfield, 16
Centronella impressa, 18
Ceratopora dichotoma, 14
Chemung sandstones and shales, 6, 30
Chenango county, Moscow shale, 19
Chonetes deflectus, 20
lepidus, 14, 15, 17
mucronatus, 12, 13, 15, 20
scitulus, 13, 15, 17
setigera, 21
setigerus, 15
Cladochonus *sp.*, 27, 28, 29
Clarence, 8, 9, 12
Clarke, J. M., cited, 8, 24, 30
Cobleskill waterlime, 6, 8–9; exposures, 9
Corniferous limestone, 10
Cowlesville, 21, 22, 26
Crinoid stems, 15, 21, 29
Crittenden, 11
Crooked creek, 16
Crow creek, 27
Cryphaeus boothi, 15, 17
Cryptonella planirostra, 18
Cyathophyllum hydraulicum, 8
Cypricardinia indenta, 13
Cystiphyllum conifollis, 20

Danley Corners, 27
Darien, 16, 17, 19, 20
Darien Center, 17, 19, 20, 21, 22, 24
Diaphorostoma lineatum, 17, 18
Dunkirk black shale, 28
Durkee creek, 19, 22, 24

Digitized by Google

East Bethany, 16
East Elma, 24, 26
East Lancaster, 16
East Victor, 9
Eighteen Mile creek, 16, 19
Ellicott creek, 6, 8, 12, 13, 17, 19, 20, 21, 22, 24
Elma, 17
Encrinal limestone, 18
Euomphalus (Phanerotinus) laxus, 15
Euthydesma subtextile, 28
Evans, 24, 26

Fallkirk, 9
Favosites *sp.*, 9
hamiltoniae, 18
Flint creek, 13
Folsomdale, 26

Gardeau flags and shales, 6, 26, 27–28; exposures, 28
Genesee black shale, 6, 21–22; exposures, 22
Genesee county, gypsum beds, 7
Genesee river, 29
Genesee River gorge, 19, 25, 26, 28
Genesee River valley, Wiscoy shales, 29
Genesee slate, 21
Genundewa limestone, 6, 22–23
Genundewa point, 22
Gephyroceras, *sp.*, 23
genundewa, 23
Grabau, A. W., cited 16, 18, 19, 30
Grimes sandstones, 27
Griswold, 20, 21, 22, 24, 25
Gyroceras trivolve, 11
undulatum, 11

Hall, James, cited, 18, 25, 26, 30
Hamilton beds, 6, 15–30
Hatch shales and flags, 6, 26–27; exposures, 27
Honeoye Falls, 10
Honeoyea desmata, 28
erinacea, 28
major, 25, 28
styliophila, 23
Hunters creek, 27
Hydnoceras nodosum, 28
Hyolithes neapolis, 29

Indian Falls, 7, 9
Isochilina? fabacea, 12

Jewettville, 26, 27

Keuka Lake valley, 26

Lake Como dam, 13
Lancaster, 6, 12, 13, 14
Leperditia scalaris?, 7, 8
Leptaena rhomboidalis, 11
Leptostrophia perplana, 17, 20
LeRoy, 14
Lingula ligea, 24, 25, 29
spatulata, 23
Liorhynchus limitare, 12, 13, 14, 15
multicostum, 17
Little Buffalo creek, 14, 16, 20, 21, 24
Livingston county, Cashaqua shale, 25
Gardeau flags and shales, 27
Genesee black shale, 21
Genundewa limestone, 22
pyrite, 20
Long Beards riffs, 29
Loomis, F. B., cited, 20
Loxonema?, 9
multiplicatum, 28
noe, 23
Ludlowville shale, 6, 16–17, 19; exposures, 17
Lunulicardium (Pinnopsis) acutirostrum, 25
bickense, 28
curtum, 23
ornatum, 25
wiscoyense, 29
Luther, D. D., cited 30

Manlius limestone, 9
Manticoceras oxy, 27, 28, 29
pattersoni, 23, 25, 27, 28
rhynchostoma, 27, 28, 29
sororium, 27
Marcellus, upper shales of, 14
Marcellus black shale, 6, 12–13; exposures, 13

Digitized by Google

Marilla, 17, 20, 21, 22, 24
Marilla Station, 17
Melocrinus clarkei, 23, 25
Meristella barrisi, 13, 14
Middlesex black shale, 6, 23, 24
Mill Grove, 12
Modiomorpha concentrica, 18
subalata, 17
Morganville, 9, 10
Moscow, 19
Moscow shale, 6, 19–20; exposures, 20
Murder creek, 16, 17, 19, 20, 21, 22, 24, 25, 26

Nautilus magister, 17
Nematophyton crassum, 9
North Evans, 19
North LeRoy, 9
Nuculites triquet..,.12, 15
Nunda sandston^, 6, 28–29; exposures, 29

Oakfield, 7
Odontocephalus selenurus, 11
Onondaga county, gypsum beds, 7
Onondaga limestone, 6, 10–12; exposures, 11–12
Ontaria accincta, 25
clarkei, 28
suborbicularis, 23, 25, 27, 28
Ontario county, Gardeau flags and shales, 27
Genesee black shale, 21
Genundewa limestone, 22
Moscow shale, 19
Tully limestone, 20
Orbiculoidea, 23
sp., 29
minuta, 14
Oriskany sandstone, horizon, 6, 9–10; exposures, 10
Orthoceras *sp.*, 15, 29
aegea, 14
atreus, 23
exile, 13
filosum, 25
marcellense, 13
nuntium, 17
ontario, 25
Orthoceras pacator, 25, 28
subulatum, 12
mut. pygmaea, 21
Orthothetes arctostriatus, 15, 17
interstriatus, 9

Paleoneilo petila, 25
tenuistriata, 17, 20
Paleotrochus praecursor, 28
Panenka *sp.*, 23
Paracardium doris, 23, 25, 27, 28, 29
Paracyclas lirata *mut.* pygmaeus, 21
Parsons Corners, 29
Phacops cristata, *var.* pipa, 11
rana, 13, 14, 15, 17, 18, 20
Phelps, 10, 13
Pholidops hamiltoniae, 20
Phragmostoma natator, 23, 25, 28
Pike creek, 18, 22, 24
Platyceras auriculatum, 17
thetis, 17
Pleurotomaria, 9, 21
sp., 29
genundewa, 23
rugulata, 23
Pleurodictyum stylopora, 17
Plumb Bottom creek, 13, 14
Poland hill, 29
Portage beds, 6
Portageville, 28
Porterville, 26
Posidonia attica, 28
Primitiopsis punctulifera, 13
punctuliferus, 15
Probeloceras lutheri, 25
Productella spinulicosta, 15
Proetus rowi, 17
Pterinea flabellum, 17
Pterochaenia cashaqua, 25
fragilis, 12, 14, 15, 21, 23, 25, 27, 28
Pyrite in Tully horizon, 5, 20–21

Rhinestreet black shale, 6, 26
Rhipidomella penelope, 18
vanuxemi, 17, 18
Rhynchonella *sp.*, 9
Rondout waterlime, 9
Ruedemann, Rudolph, cited, 8

Digitized by Google

Seneca limestone, 10
Shaffer creek, 16
Sheldon, 28
Sierks, 26
Skaneateles lake, 15
Skaneateles shale, 6, 15–16; exposures, 16
Smoke creek, 13
South Attica, 29
Spirifer acuminatus, 11
consobrinus, 20
divaricatus, 11
eriensis, 9
fimbriatus, 17
mut. pygmaeus, 21
granulosus, 17, 18
mut. pluto, 21
mucronatus, 15, 17, 18
mut. hecate, 21
subumbonatus, 13, 17
tullius, 20
Spring Brook, 18, 19, 20, 21, 22, 24
Spring creek, 17
Stafford, 13, 14
Stafford limestone, 6, 13–14; exposures 13–14
Stony Brook, 29
Stony Brook ravine, 28
Streptelasma rectum, 17, 20
Strophalosia truncata, 12, 13, 15
Stropheodonta concava, 11
demissa, 17
inequistriata, 11
Styliola limestone, 22
Styliolina fissurella, 12, 14, 15, 17, 21, 22, 23, 28

Tannery brook, 24, 25, 26, 27
Tentaculites gracilistriatus, 15, 20
Tichenor limestone, 6, 16, 18–19; exposures, 18–19
Tichenor point, 18
Tonawanda creek, 6, 7, 26, 28
Tornoceras uniangulare, 14, 21, 23, 25, 27, 28
Trochoceras gebhardi, 9
Tropidoleptus carinatus, 15, 17, 18
Tully horizon, 20–21

Union Springs, 9

Vanuxem, Lardner, cited, 14, 15
Varysburg, 28, 29, 30
Vitulina pustulosa, 18

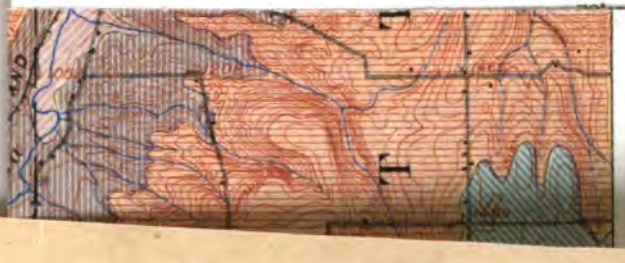
Wales Center, 27
Websters Corners, 19, 20
Wende, 13
West Alden, 19, 20
West River shale, 6, 23–24; exposures, 24
Whitfieldella laevis, 8, 9
nucleolata, *var.*, 9
sulcata, 9
Williamsville, 8, 9, 12
Wiscoy shale, 6, 29–30; exposures, 30

Yates county, Middlesex black shale, 24
West River shale, 23

Zaphrentis *sp.*, 29

Digitized by Google

ATTICA--DEPEW QUADRANGLES BULLETIN 172



LEGEND

Rhinestreet black shale

Hatch shales and flags

Geologic map of the Attica-Depew quadrangles

78° 15'

Field work by D. D. Luther
1909

Digitized by Google

Digitized by Google

S-M A-N
NOV 5 1914
11983

University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the act of August 24, 1912

Published fortnightly

No. 578 ALBANY, N. Y. NOVEMBER 1, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 173

TENTH REPORT OF THE DIRECTOR OF THE STATE MUSEUM AND SCIENCE DEPARTMENT

INCLUDING THE 67th REPORT OF THE STATE MUSEUM, THE 33d REPORT OF THE STATE GEOLOGIST, AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1913

		PAGE
Introduction		3
I	Condition of the new Museum	4
	New Museum cases	5
	Progress of installation	29
II	Report of the Geological Survey	36
	Civic geology	36
	Board of Geographic Names	43
	Areal geology	58
	Surficial geology	67
	Industrial geology	69
	Mineralogy	73
	Paleontology	73
III	Report of the State Botanist	80
IV	Report of the State Entomologist	84
V	Zoology	90
VI	Report of the Archeologist	93
VII	Publications	103
VIII	Report on the collection of coins, medals and paper money	107
IX	Staff of the Department of Science	109
X	Accessions	111
Appendix		142
	The Origin of Man (adapted from paper by Dr E. Rivet)	142
Index		157

ALBANY
THE UNIVERSITY OF THE STATE OF NEW YORK
1914

M48r-Ap14-2500

A

Digitized by Google

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of the University

With years when terms expire

1917 St Clair McKelway M.A. LL.D. D.C.L. L.H.D.
Chancellor Brooklyn
1926 Pliny T. Sexton LL.B. LL.D. *Vice Chancellor* Palmyra
1915 Albert Vander Veer M.D. M.A. Ph.D. LL.D. Albany
1922 Chester S. Lord M.A. LL.D. - - - - - New York
1918 William Nottingham M.A. Ph.D. LL.D. - - Syracuse
1921 Francis M. Carpenter - - - - - - - - Mount Kisco
1923 Abram I. Elkus LL.B. D.C.L. - - - - - New York
1924 Adelbert Moot - - - - - - - - - - Buffalo
1925 Charles B. Alexander M.A. LL.B. LL.D. Litt.D. Tuxedo
1919 John Moore - - - - - - - - - - - Elmira
1920 Andrew J. Shipman M.A. LL.B. LL.D. - - New York
1916 Walter Guest Kellogg B.A. - - - - - Ogdensburg

President of the University and Commissioner of Education

John H. Finley M.A. LL.D.

Assistant Commissioners

Augustus S. Downing M.A. L.H.D. LL.D. *For Higher Education*
Charles F. Wheelock B.S. LL.D. *For Secondary Education*
Thomas E. Finegan M.A. Pd.D. LL.D. *For Elementary Education*

Director of State Library

James I. Wyer, Jr, M.L.S.

Director of Science and State Museum

John M. Clarke Ph.D. D.Sc. LL.D.

Chiefs of Divisions

Administration, George M. Wiley M.A.
Attendance, James D. Sullivan
Educational Extension, William R. Watson B.S.
Examinations, Harlan H. Horner B.A.
History, James A. Holden B.A.
Inspections, Frank H. Wood M.A.
Law, Frank B. Gilbert B.A.
Library School, Frank K. Walter M.A. M.L.S.
Public Records, Thomas C. Quinn
School Libraries, Sherman Williams Pd.D.
Statistics, Hiram C. Case
Visual Instruction, Alfred W. Abrams Ph.B.
Vocational Schools, Arthur D. Dean D.Sc.

Digitized by Google

The University of the State of New York
Department of Science, March 16, 1914

Dr John H. Finley
President of the University

SIR: I have the honor to transmit herewith my annual report as Director of the State Museum for the fiscal year ending September 30, 1913, and to recommend it for publication as a Museum bulletin.

Very respectfully
JOHN M. CLARKE
Director

Approved for publication this 18th day of March 1914

President of the University

Digitized by Google

Digitized by Google

Digitized by Google

A restoration of one of the oldest trees of the earth
(Archeosigillaria primeva)

Recently erected in the State Museum and reconstructed from a specimen found in the Devonic rocks of Naples, N. Y.

Digitized by Google

University of the State of New York Bulletin

Entered as second-class matter August 2, 1913, at the Post Office at Albany, N. Y., under the act of August, 12, 1912

Published fortnightly

No. 578 ALBANY, N. Y. NOVEMBER 1, 1914

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 173

TENTH REPORT OF THE DIRECTOR OF THE STATE MUSEUM AND SCIENCE DEPARTMENT

INCLUDING THE 67TH REPORT OF THE STATE MUSEUM, THE 33D REPORT OF THE STATE GEOLOGIST AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1913

INTRODUCTION

This report covers all divisions of the scientific and other Museum work under the charge of the Regents of the University and concerns the progress made therein during the fiscal year 1912–13. It constitutes the 67th consecutive annual report of the State Museum, the 33d annual report of the State Geologist (consecutive since 1881) and the report of the State Paleontologist for 1913. It is introductory to all memoirs, bulletins and other publications issued from this Department during the year named.

The committee of the Board of Regents having supervision of the affairs of this Department are the Honorables: Charles B. Alexander M.A. LL.B. LL.D. Litt.D., Tuxedo; Francis M. Carpenter, Mount Kisco; Lucius N. Littauer B.A., Gloversville.

The subjects presented in this report are considered under the following chapters:

I Condition of the New Museum and Progress in Installation
II Report on the Geological Survey
III Report of the State Botanist
IV Report of the State Entomologist
V Report on the Division of Zoology

Digitized by Google

VI Report on the Division of Archeology and Ethnology
VII Report on the Publications of the Department for the Year
VIII Report on the Collection of Coins and Medals
IX Staff of the Department
X Accessions to the Collections
XI Appendixes (to be continued in subsequent volumes)

I

CONDITION OF THE NEW MUSEUM

The entire energy of this staff has been given, during the past year, almost without reserve, to the equipment of the Museum halls and offices. The transfer of the collections from the State Hall, Geological Hall, Universalist church, Taylor brewery (storehouse) and other buildings which had been utilized for storage, began in October last and the process of moving continued throughout the winter. It was unavoidable that in spite of every precaution in such removal, a state of confusion should ensue, and even the temporary arrangement of this great accumulation of scientific material in such form as to make it accessible for installation and orderly storage made the utmost demands on the industry and patience of the staff. Every man has given his best service to the relief of conditions which constantly exacted laborious manual work and unremitting good nature.

At the time of this removal there were no cases in which the collections could be installed or stored except the few brought over from other buildings, which it was the intention to use temporarily. Boxes, crates, barrels and drawers were piled up on the bare floors, with such attempts at arrangement as could be made under the urgent pressure of a moving contract. In March the parts of the new Musuem cases which have been under construction by George W. Cobb, jr, were delivered and final assembling of them has continued throughout the year. These conditions falling together made the problems of installation peculiarly trying, requiring the unpacking of the materials while there was no case room available for them. But the selection and preparation of the collections proceeded with such temporary expedients as could be devised while the construction of the cases went on with the deliberation essential to good workmanship.

Digitized by Google

NEW MUSEUM CASES

The contract for the new case equipment called for 384 cases of 28 different types. The general design and plans were worked out by the scientific staff with special reference to their adaptation to distinctive exhibits. These cases are now all completed and it may be well to give herewith, as a matter of record, a brief notice of the several types and styles of construction. In selecting the materials for these cases, it was determined to avoid, so far as possible, the use of metal. The action of the metal and the oak cases under the conflagration conditions of the Capitol fire left barely a choice in this matter, and after full consideration by the Regents committee specially charged with the letting of the contract, it was deemed wise to avoid metal except in the construction of the cases for the herbarium. Wood and plate glass, being determined upon as the essential construction materials, in order to avoid monotony of color, mahogany was selected for the wood in the cases for the Zoology, Paleontology and Archeology Halls, ebonized cherry for the Geology and Mineralogy Halls. The following brief exposition of their composition and projection has been prepared by Mr Whitlock.

EXHIBITION AND STORAGE TYPES

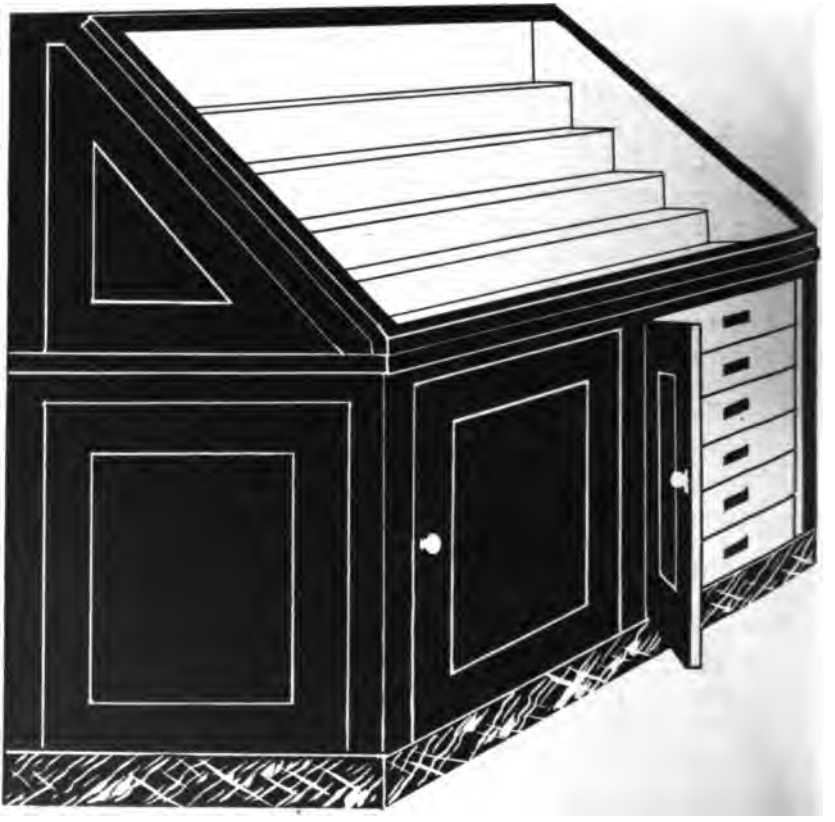
Type B. Cases of type B were designed primarily for the exhibition of the general collection of minerals. They have, however, been adopted throughout other sections of the Museum to such an extent that over 50 per cent of the exhibition cases are included under this type. Type B must therefore be regarded as a case adapted to the combined display and storage of small or medium sized objects which it is desirable to show in rows close enough to the eye to admit of the objects being seen in detail. This applies to small fossils, minerals, hand specimens of rock, shells, birds' eggs and small archeological objects, such as pipes, bone implements, etc. The design of this case was modified from one in use in the mineralogical museum of Columbia University, which in turn was derived from a style of case in the University Museum at Prague.

The exhibition space of this type case consists of a triangular prism 5 feet long by 2 feet 3 inches wide by 2 feet 3 inches high, the deck being raised to a level of 3 feet 1½ inches from the floor level. This exhibition space is accessible by one single-panel lid

Digitized by Google

inclined, hinged at the top. Removable steps, in two sections to the case, are provided for the display of small specimens, giving five levels with about 25 feet of shelf length in each case.

The space below the exhibition portion of the case is furnished with 12 drawers in 2 rows, inclosed by wooden doors which lock with the same key as the lid of the exhibition portion.

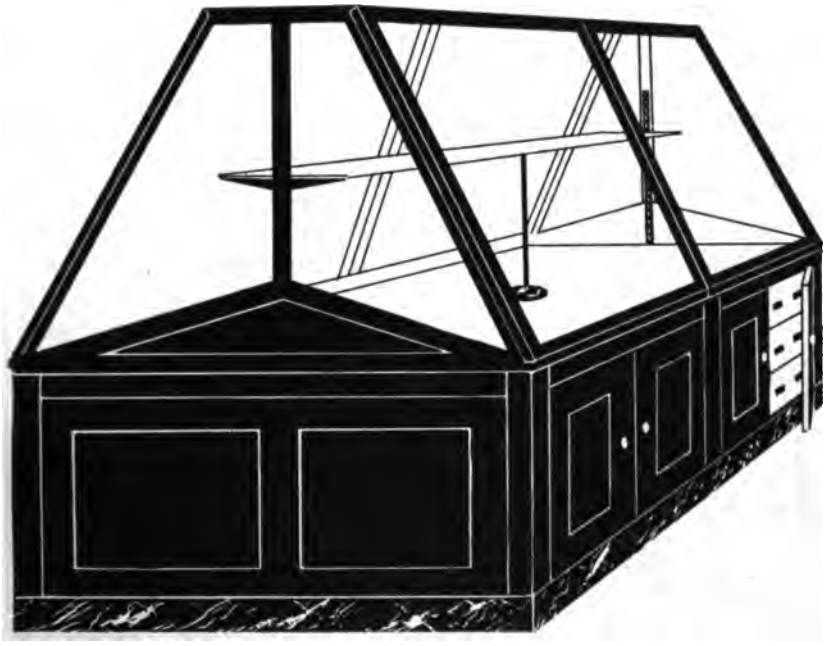


TYPE B

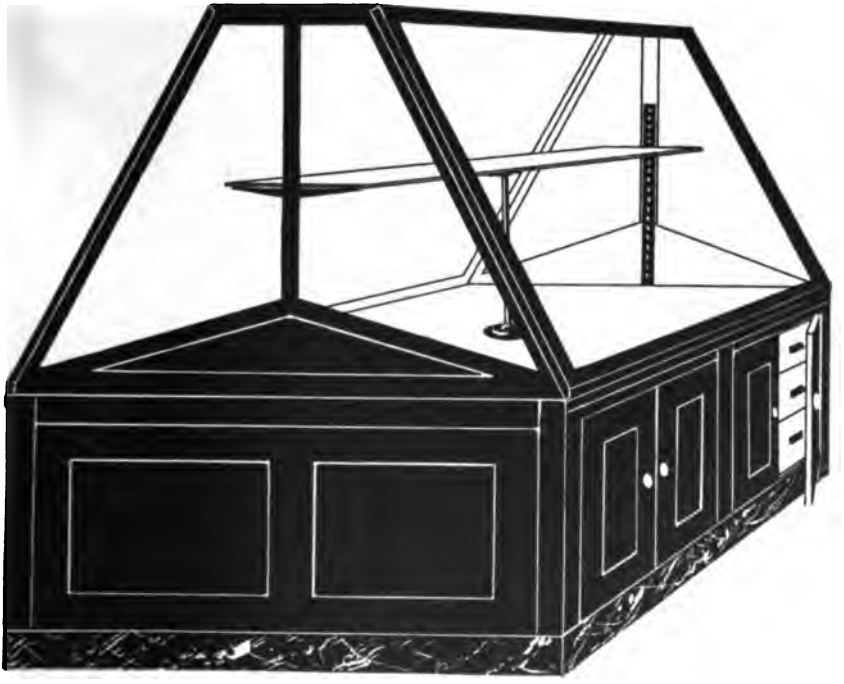
The type B cases are in most instances assembled back to back in blocks of four.

Types C and D. Types C and D are essentially the same, the only difference being that C is 2 feet longer than D. Both types are designed for the display of archeological specimens in definite groupings, such as articles from a grave, series of objects showing method of manufacture, comparison of the same sort of articles, etc.

Digitized by Google



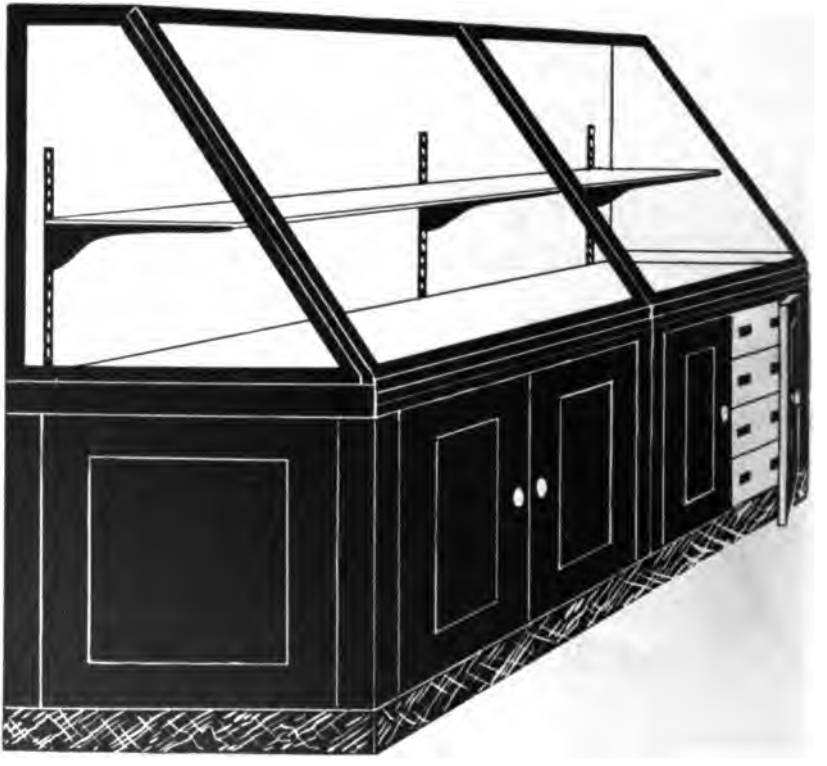
TYPE C



TYPE D

Digitized by Google

The exhibition space is in the form of a truncated wedge 8 feet (6 feet for D) long by 4 feet 6 inches wide by 2 feet 10 inches high with sloping sides on the long dimension and inclosed on the sides, the exposed ends and the top with glass. The deck of this exhibition space is raised 3 feet from the floor level, the space below being furnished with 24 drawers in 8 rows (12 drawers in 4 rows for D) inclosed by wooden doors. A removable glass shelf running the length of the exhibition space 1 foot 4 inches above the deck furnishes a second level upon which specimens may be displayed. Access to the exhibition space may be obtained on the two long



TYPE E

sides by means of doors hinged at the top. The cases are grouped in rows of three, giving aisles 24 feet and 16 feet for C and D respectively.

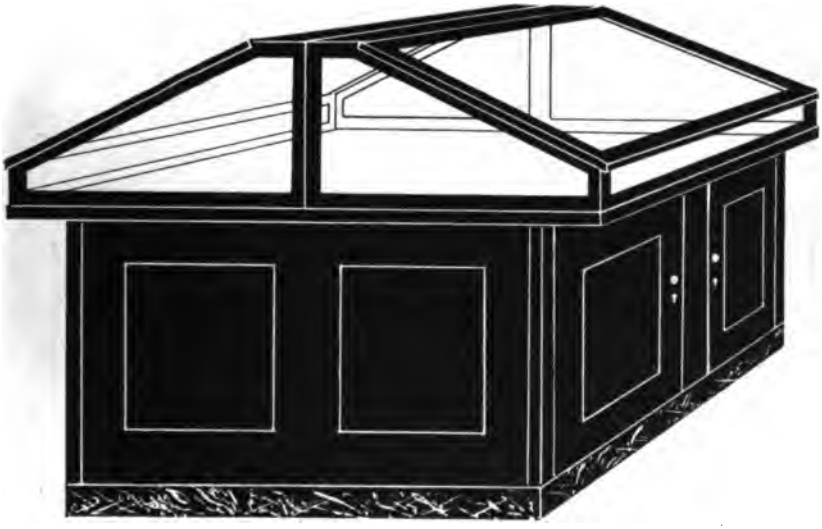
Type E. Type E is an adaptation of the type C intended to

Digitized by Google

occupy space next to the wall. It is consequently constructed as the longitudinal half of C, somewhat widened (2 feet 9 inches wide) to give it proportion, and closed at the back where it comes in contact with the wall. It is designed to display the same series of objects as types C and D.

The storage space consists of 16 drawers arranged in 4 rows of 4. The cases as at present installed stand singly against the south wall of the west mezzanine.

Type F. Type F is specially adapted to the display of such groupings as lend themselves to a flat display treatment, such as feather ornaments, war clubs, wampum belts, etc. Consequently, the level of the exhibition space is somewhat lower with respect to the floor level and the space proportionately low to its length and width; in other words, type C has been flattened out to meet the needs for the display of flatter objects.



TYPE F

The exhibition space is in the form of a low wedge 5 feet long by 5 feet wide and 1 foot 3 inches high, the top, sides and ends of which are glazed. The inclined tops form the lids and the exhibition space somewhat overhangs the supporting storage portion to give better symmetry to the general case outline.

The storage portion is furnished with a bottom and one shelf on both sides of the case closed with wooden doors.

Digitized by Google

As installed at present, the type F cases are free standing, that is, accessible on all four sides.

Type G. Type G combines the longitudinal half of type F lengthened and adapted to the space next the wall, with a superposed wall case section. The object of this type of case is to show

TYPE G

in proximate relation objects which are more or less flat and those, such as garments, head dresses, etc., which require to be displayed on a vertical surface. This practically results in two exhibition

Digitized by Google

spaces, the lower of which, corresponding to a longitudinal half of type F, is 8 feet long by 3 feet wide by 1 foot 4 inches high, opening in two single-panel glazed lids. The upper or vertical exhibition space is 8 feet long by 10 inches wide by 3 feet 9 inches

TYPE A

high, occupying a vertical space from the floor level of roughly from 4 to 8 feet, and opening by means of four single panel doors.

The storage space is shelved similar to type F.

Type A. Type A was designed to exhibit specimens of fossils and was adapted from a similar type of case in use in the National

Digitized by Google

Museum at Washington. The case is "free standing," that is, open to view on all four sides. It measures 8 feet long by 3 feet wide by 8 feet high and the deck or case flooring is 1 foot 11 inches above the general floor level. Access to the cases is obtained through double doors on both long sides which admit of the easy arrangement of specimens in every portion of the exhibition space. A wooden diaphragm for the support of slabs is fitted inside each case, attached in such a way as to be readily removable should the free case space be required for the display of large objects. The diaphragms are in the form of rectangular, truncated pyramids of steep inclination and are provided with narrow cleatlike projections, running continuously around the diaphragm at convenient

TYPE H

levels, to provide for the mounting of specimens on all four sides of the case.

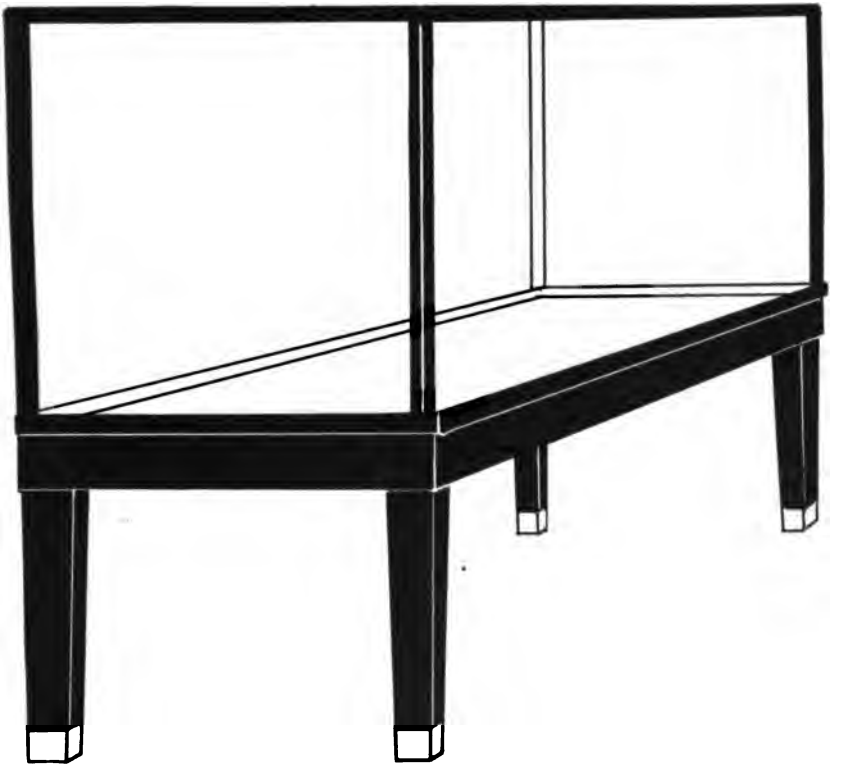
SPECIAL ENTOMOLOGY TYPE

Type H. Type H was designed to exhibit insects mounted on flat surfaces in proximate relation to descriptive groups showing the life history of typical members of the series illustrated in the flat exhibits. The general design of this case somewhat resembles the entomological cases of the American Museum of Natural History known as the "A" and table cases combined, but with the

Digitized by Google

added feature of a middle upright section in the shape of a rectangular exhibition space for the display of the life history groups.

The exhibition space is divided into three sections in which each of the two end sections consists of two shallow flat elements on either side of the longitudinal axis opening by hinged lids and surmounted by narrow vertical elements with slightly inclined sides, one of which is removable for the insertion of a double diaphragm



TYPE I

to hold the specimens which are consequently visible from both sides of the case. In the middle section, the vertical element is rectangular and is not provided with a diaphragm. The horizontal elements are 4 feet long by 1 foot 10 inches wide by 6 inches deep, the decks and lids are parallel and slightly inclined from the horizontal, the former being 2 feet 2 inches at the outside and 2 feet 6 inches at the inside line.

Digitized by Google

The upright end element is 4 feet long, 1 foot 3 inches wide at the bottom and 2 feet high. The same dimensions hold for the middle element except that this latter is 2 feet 3 inches high. The deck for all the upright elements is 3 feet 2 inches from the floor level. The case is supported on legs and covers a floor space of 12 feet by 5 feet.

FREE STANDING TYPES FOR LARGE SPECIMENS

In the free standing types of cases are represented the extremes of simplicity in case design, in that they involve primarily a deck

TYPE J

or exhibition floor supported on legs and inclosed in glass to a height which gives sufficient head room for the required exhibit.

Type I. Type I represents a "general utility" case for the display of large objects such as mineral or geological specimens, series of specimens in industrial geology and paleontology. This type can also be used to advantage for the display of models of mine workings, industrial plants, etc. The exhibition space is rectangular and measures 6 feet long by 3 feet wide by 3 feet high and

Digitized by Google

is mounted on legs to raise the deck 2 feet 6 inches from the floor level. Access is obtained by removing one of the long sides by means of removable screws which work in brass sockets. In practice, the interior may be furnished with block-steps or diaphragms depending on the nature of the material to be exhibited,

TYPE K

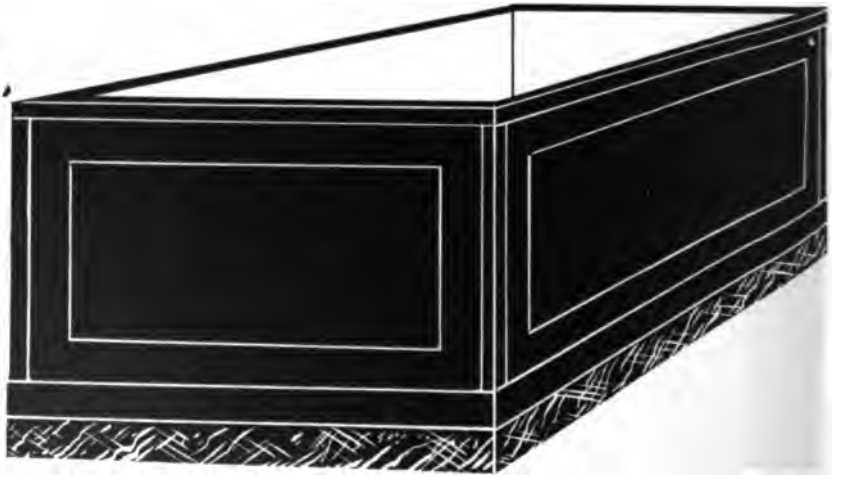
the proportions of the exhibition space yielding much latitude of treatment in this respect.

Type J. Cases of type J are also designed for the display of definite specimens, that is, large minerals of a special occurrence. They are intended to be used without diaphragms or step-

Digitized by Google

blocks and to be installed in a group of which the single type L case forms a center. The exhibition space is in the form of a truncated wedge of which the base is 8 feet long by 3 feet wide and is raised 3 feet above the floor level.

Type K. Type K cases differ from type I only in size and proportions. They are intended for the display of the larger slabs of fossil remains which, on account of their development of fine detail, need to be closer to the eye of the observer than would be possible in a deck as close to the floor level as that of type I. The rectangular exhibition space which measures 4 feet long by 2 feet 6 inches wide by 2 feet 6 inches high, is consequently raised to a level of 3 feet from the floor level. For the interior furnishing of these cases narrow, high diaphragms or step-blocks are best adapted



TYPE M M

both from the point of view of the proportion of the material to be exhibited and from that of the proportions of the exhibition space.

Type L. Unlike the preceding types, this case design, of which only one was installed, was made to accommodate one particular specimen, a large crystal of calcite installed in the Mineralogy Hall. The exhibition space is rectangular, measures 4 feet 6 inches square by 2 feet high, and is raised 2 feet 6 inches above the floor level.

ARCHEOLOGY EXCAVATION TYPES

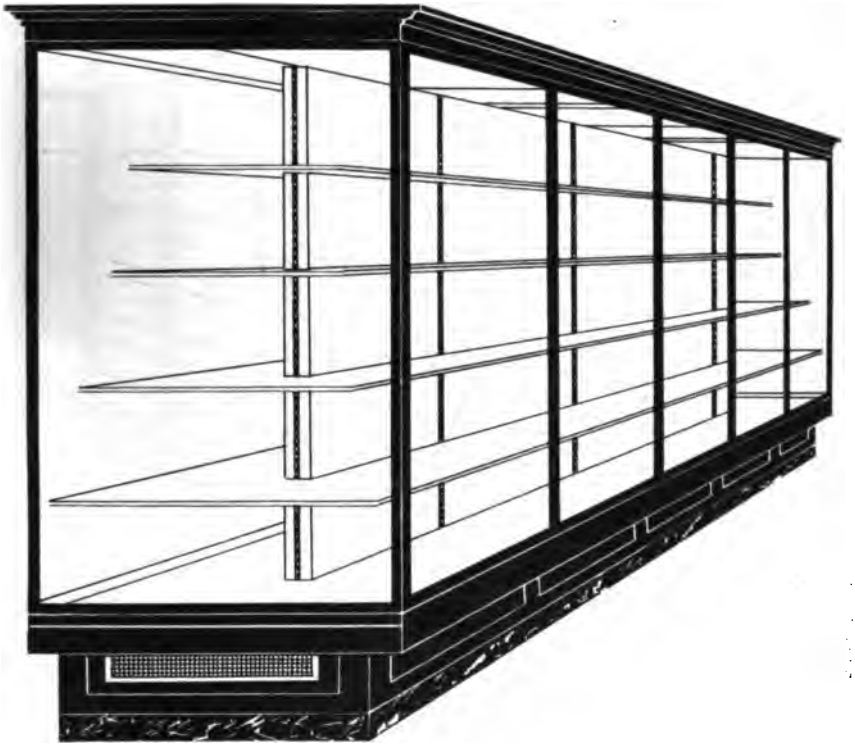
The archeology excavation types of cases consist essentially of rectangular boxes 3 feet in height, setting directly on the floor.

Digitized by Google

They are designed for the exhibit of reproductions of Indian grave excavations to be viewed through the glass lid which may be removed to gain access to the case. The two types, M and MM, differ only in one dimension, being 5 feet (6 feet for MM) long by 4 feet wide by 3 feet high. They are designed to be free standing, but may be installed with one side against the wall.

TYPES WITH ADJUSTABLE SHELVES AND WALL-CASE TYPES

Under the group of types with adjustable shelves and wall-case types are included the various forms of wall cases and the detached



TYPE N

type with shelves which may for purposes of classification be considered a detached pier wall case. The group of types is characterized by a low deck and a uniform height of about 8 feet, the limit between which zoological and archeological specimens may be seen to advantage, the exception to the 8 foot height in cases of this

Digitized by Google

group being type Q, which was designed for a children's exhibit in archeology. The longitudinal dimension in wall type cases is, of course, limited by the length of wall space to be filled and the lateral dimension by the character of the material to be exhibited; for instance, for large mammals or Indian canoes, a fairly wide wall case is required, while for Indian garments, ceremonial masks

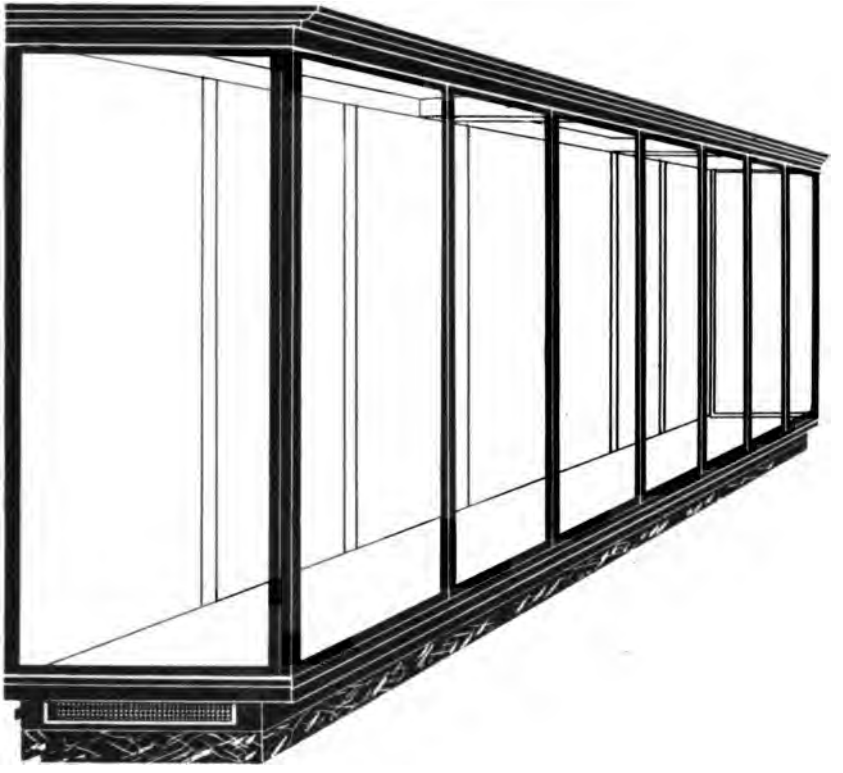
TYPE O

or rows of bottled alcoholic specimens of invertebrates, a comparatively narrow wall case is best adapted. In the large zoology types of this group two features appear for the first time in this description: (1) The base is recessed in order to permit the ob-

Digitized by Google

server to stand close to the glass. By this means an economy of aisle room is effected. (2) A ventilating device is introduced in the base by means of which the air passing into the case when pressure is equalized, after a sudden change of temperature, is filtered free of dust through a series of sheets of cotton.

Type N. Cases of type N were designed for the display of the general collection of New York small mammals, birds, fishes etc. The exhibition space is 16 feet long by 4 feet wide and 6 feet



TYPE P

6 inches high, raised on the recessed base 1 foot 6 inches from the floor level. The case is divided longitudinally by a substantial diaphragm furnished with slotted strips upon which adjustable brackets are fastened which in turn support the wooden shelves. Access is gained through the second and fourth panels on both sides and the two end panels which are hinged doors. The top panels are glazed. The cases as at present installed are free standing arranged

Digitized by Google

with an aisle of about 10 feet between cases and an aisle of about 4 feet between the ends of the cases and the wall, giving an alcove effect in arrangement.

Type O. The two cases of type O are distinctly wall cases. They were designed for the display of small zoological specimens,

TYPE PP

models and preparations to illustrate the invertebrate fauna of New York. The type is consequently narrow compared with its length and has its glass shelves spaced closer together than those of type N. The exhibition space is 14 feet long by 1 foot 6 inches

Digitized by Google

wide by 6 feet 6 inches high and is raised on a recessed base 1 foot 6 inches from the floor level. Access is gained through the second and fourth panels which are swinging doors. The glass shelves are adjustable on bronze brackets supported from the back on slotted strips. The top panels are glazed.

Type P. Type P is a single wall case occupying the space between the entrances of the Zoology Hall. It is designed for the display of groups of the larger birds, such as eagles and hawks.

TYPE Q

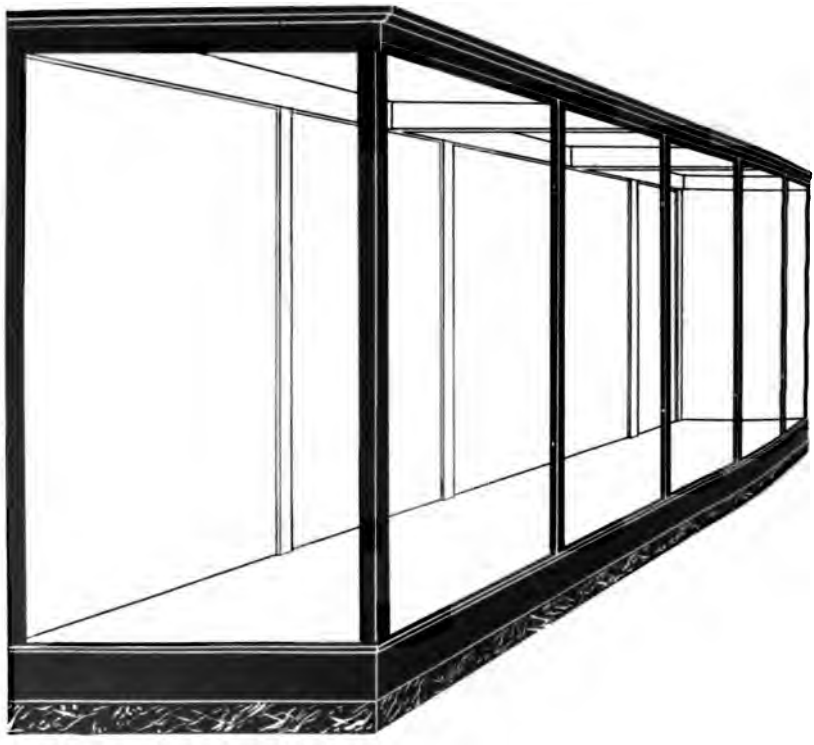
The exhibition space is consequently unbroken by shelves, is 19 feet long by 3 feet wide by 7 feet high and is raised 1 foot above the floor level on a recessed base. On account of the size of the exhibition space the case is ventilated with the dust-filtering device. The first, third, fifth and seventh panels are hinged, giving access to the case. The top panels are glazed.

Type PP. The wall cases of type PP are planned for the display of the larger archeological specimens such as baskets, canoe

Digitized by Google

paddles, pestles and mortars for pulverizing maize, etc. The exhibition space measures 10 feet long by 3 feet wide by 7 feet high and is raised 1 foot above the floor level. The glass shelves are supported on adjustable bronze brackets. The top panels are glazed. Access is gained through the first and third panels which are hinged on the end side.

Type Q. The two wall cases of type Q are intended for a children's exhibit of objects relating to Indian life and customs. The



TYPE R

cases are consequently two feet lower than the customary height for wall cases. The exhibition space is 8 feet long by 3 feet wide by 5 feet high and is raised 1 foot above the floor level. The first and third front panels are hinged on the end sides giving access to the case. The top panels are glazed. The glass shelves are supported on adjustable bronze brackets and are divided between brackets into three units for each level so that a panel of shelving or

Digitized by Google

any level of a panel can be eliminated to give head room for larger specimens.

Type R. The single case of type R was designed for the display of Indian canoes in the Archeology Hall. The case is con-

TYPE S

Digitized by Google

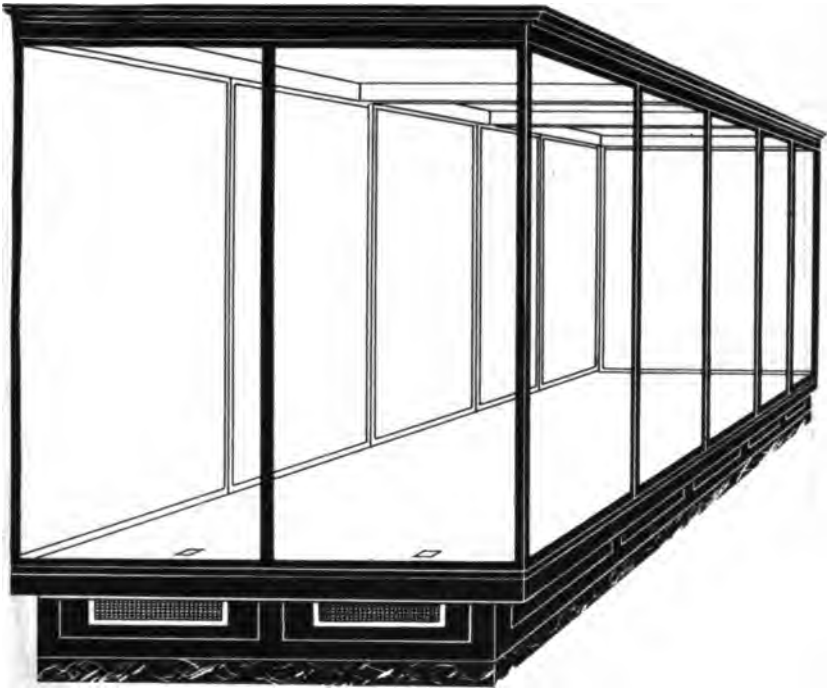
sequently longer and wider than is usual with wall cases and is not provided with shelves, the canoes being hung from the top of the case or supported on brackets from the back. The exhibition

TYPE T

Digitized by Google

space is 20 feet long by 4 feet wide by 7 feet high and is raised 1 foot above the floor level. The case is accessible through the first, third and fifth front panels which are hinged. The top panels are glazed.

Type S. Wall cases of type S were designed for the display of skulls in the collection of New York anthropology. The exhibition space is 8 feet long by 1 foot 6 inches wide by 7 feet high and is raised 1 foot above the floor level. Access is gained through



TYPE NN

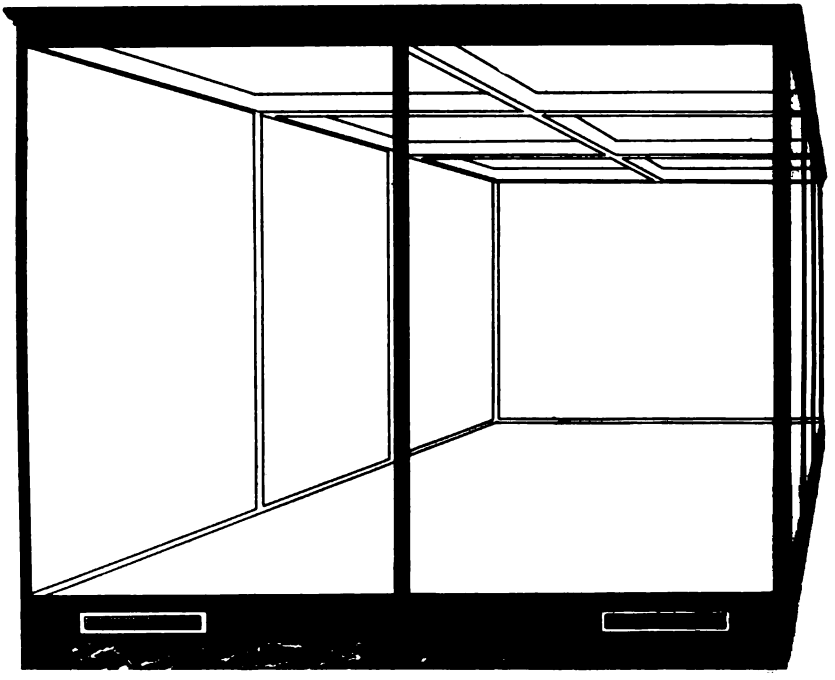
the first and third front panels which are hinged on the end sides. The top panels are glazed. The glass shelves are supported by adjustable bronze brackets.

Type T. Wall cases of type T were designed to display such specimens in the ethnology and anthropology collections as complete Indian skeletons, clothing and miscellaneous ethnology objects. The exhibition space is 6 feet long by 2 feet wide by 7 feet high and is raised 1 foot above the floor level. The top panels are glazed. Access is gained through double doors in front.

Digitized by Google

LARGE FREE STANDING CASES FOR MAMMALS AND MAMMAL GROUPS

With the exception of type NN, the large cases for mammals are each designed to contain a certain definite group, as the moose group or the puma group, mounted to show the natural surroundings and habits of the animals. Type NN cases are here included because their museum function connects them more closely with the large mammal cases, but structurally they belong with the type N cases to which they conform in general design and with which they form a continuous series running around three sides of the Hall of Zoology. The ventilating dust-filter device is used on all cases of this group of types.

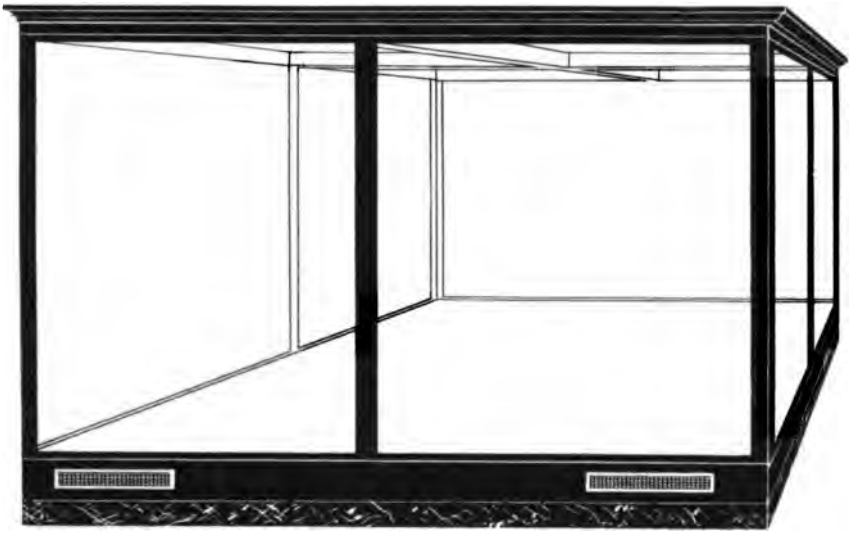


TYPE U

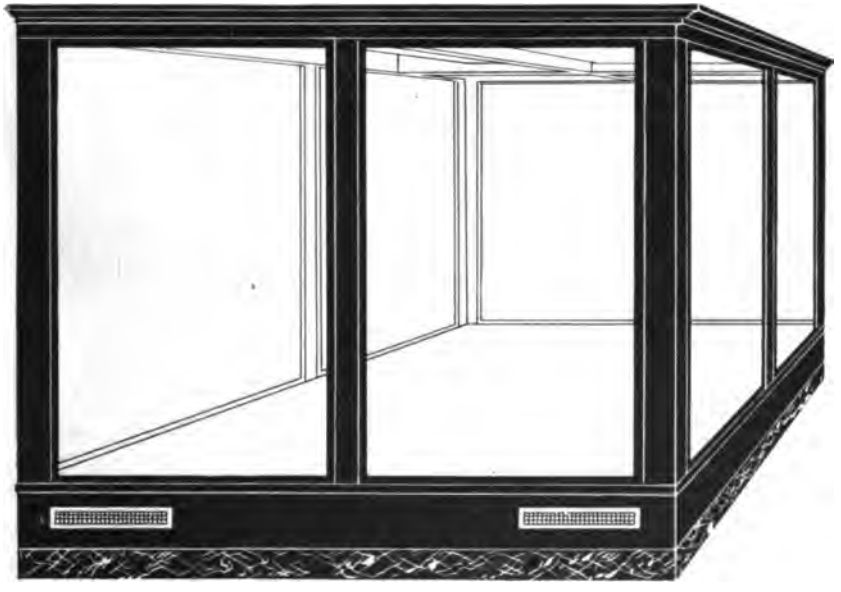
Type NN. The two cases of type NN were designed for the display of large mammals and groups of the smaller mammals in the collection of New York fauna. In design they are very closely related to type N cases, differing from the latter only in width. The exhibition space is 16 feet long by 6 feet wide by 6 feet 6 inches high and is raised 1 foot 6 inches from the floor level on a recessed base.

Digitized by Google

Types U, V, W, X and Y. Case types U, V, W, X and Y were designed to contain the large mammal groups of New York fauna. They differ from one another only in the dimensions of the exhi-



TYPE X



TYPE Y

Digitized by Google

bition space which is governed by the proportions of the group. They are all mounted on a straight (nonrecessed) base which is 1 foot high in the larger types U, V and W and 1 foot 3 inches high in types X and Y. Access to cases of these types is gained through one of the glazed top panels which is removable. Ground glass, instead of plain plate glass, is used for the top panels in order to cut off the view of the ceiling of the hall and thus render the group more detached. The sizes of the exhibition spaces are:

	Long	Wide	High
Type U	16 feet	12 feet	8 feet
V	14 "	12 "	9 "
W	10 "	10 "	7 "
X	10 "	8 "	5 " 9 inches
Y	8 "	5½ "	5 " 9 "

Number and distribution of types of museum cases
(Initial equipment)

Type	Archeology Hall	Entomology Hall	Geology Hall	Mineralogy Hall	Paleontology Hall	Zoology Hall	Total
A	.....	.....	.....	.....	20	.....	20
B	30	.....	75	48	33	24	210
C	12	.....	.....	.....	.....	.....	12
D	6	.....	.....	.....	.....	.....	6
E	12	.....	.....	.....	.....	.....	12
F	6	.....	.....	.....	.....	.....	6
G	11	.....	.....	.....	.....	.....	11
H	.....	12	.....	.....	.....	.....	12
I	.....	.....	19	15	.....	.....	34
J	.....	.....	.....	4	.....	.....	4
K	.....	.....	.....	.....	11	.....	11
L	.....	.....	.....	1	.....	.....	1
M	3	.....	.....	.....	.....	.....	3
MM	1	.....	.....	.....	.....	.....	1
N	.....	.....	.....	.....	.....	14	14
NN	.....	.....	.....	.....	.....	2	2
O	.....	.....	.....	.....	.....	2	2
P	.....	.....	.....	.....	.....	1	1
PP	6	.....	.....	.....	.....	.....	6
Q	2	.....	.....	.....	.....	.....	2
R	1	.....	.....	.....	.....	.....	1
S	3	.....	.....	.....	.....	.....	3
T	2	.....	.....	.....	.....	.....	2
U	.....	.....	.....	.....	.....	1	1
V	.....	.....	.....	.....	.....	1	1
W	.....	.....	.....	.....	.....	2	2
X	.....	.....	.....	.....	.....	2	2
Y	.....	.....	.....	.....	.....	2	2
Total	95	12	94	68	64	51	384

Digitized by Google

PROGRESS OF INSTALLATION

As already intimated, the equipment of the collections has been in a measure restrained by the progressive completion of the cases. Those finished first were filled first; those which have just been completed are still vacant. The progress of this work has also depended in some measure on the condition of the collections. Some which had been on exhibition years before had been packed away in an orderly manner and judiciously selected. Others had to be taken over just as they had lain in storage for many years. The sum of the material assembled in all departments of work was very large; taken as a whole and, as was necessary, all at once, it was well-nigh overwhelming. Preliminary to any attempt at installation was the necessity of assorting these materials according to kind and quality and the selection of representative series of the best from the great preponderance of the second best. Confronted by these conditions the work of installation has proceeded well.

Mineralogy. The collections in mineralogy were removed from Geological Hall many years ago and put in storage. In dismantling the old collections everything was packed in carefully arranged consecutive order, so that on reopening these collections were in approximate readiness for installation. Having an advantage in this foresight, as well as in the fact that the mineral cases were the first to be completed, the curator, Mr Whitlock, has brought an effective installation nearly to completion. The general mineral collections and the collection of New York State minerals now occupy 78 cases at the west end of the long south hall, and it is quite probable that this section of the Museum may be opened to the public within a reasonably short time.

Geology. In illustrations of economic and structural geology the collections have proved quite deficient and every earnest effort has been made to acquire such and replenish the losses to the Museum arising from too lavish gifts to other institutions of displays made by the State Museum at various world fairs.

These efforts are bringing together the necessary materials for instructive exhibits, relating in large measure to the most active lines of mineral production in the State, but many serious problems in this section are still unsolved, and in some respects the case room is inadequate, the general treatment of Geology Hall is still ineffective and somber and much remains to be accomplished before the room can be exposed to the public. The work, in charge of Mr

Digitized by Google

Newland and Mr Jones, will eventually be brought to a successful conclusion.

Paleontology. The collections in the paleontology section which are very large, came to the new quarters in unavoidable disorder, due to the fact that the best part of them had been twice moved since the dismantling of the exhibit in Geological Hall, and the rest had in large measure been packed in boxes from five to thirty years and during this time shifted from pillar to post — from Professor Hall's laboratory to the State Hall and Geological Hall, from there to the McCredie malthouse, to the Taylor brewery — at length to this building where, for the first time since their collection, all were assembled in one place with the purpose of selection for one permanent exhibit. The boxes and crates and drawers containing this material were more than a thousand and the first and immediate problem here was to ascertain the nature and quality of their contents.

The progress made in this work is satisfactory, in view of the small number of men on the staff available for such service. The paleontology cases, 66 in number and consisting at present of four different types of construction, were made finally available in August and, except for a few of the smaller ones intended for special exhibits, all have been filled with a temporary arrangement of materials, and a final and permanent display has been worked out for certain groups of fossils: the Trilobites, Eurypterida, Crustacea and Cephalopods. This work has been carried out by Doctor Ruedemann, Mr Hartnagel and Mr Wardell.

In addition to this, much has been accomplished in the preparation of large exhibits of invertebrate fossils mounted on uncovered pedestals. Of these are a unique slab of Devonic starfish 4 feet 9 inches by 4 feet 9 inches, from Saugerties, N. Y., collected and mounted by Mr Wardell; a very striking display of cephalopods from the Agoniatite limestone, collected by Mr Hartnagel, developed by Mr Norton and mounted by Mr Wardell; a great slab of Devonic sponges from the Jenks quarry at Bath, N. Y., collected by the late C. Van Deloo, developed by Mr Norton and mounted by N. T. Clarke. Some very effective natural size reproductions of the Eurypterida, *Pterygotus, Eusarcus, Stylonurus,* have been made, framed and set up in the hall. These have been modeled by Mr Marchand and colored by Mr Barkentin. A series of natural size and enlarged relief designs to show the structure of the fossil cephalopods have been modeled by Doctor Ruedemann, cast by Mr Clarke and effectively colored by Mr Barkentin.

Digitized by Google

The fossil plants from the New York rocks will be assembled in the hall at the elevator landing. As a central piece for the room will be a restoration in life proportions of the unique Devonic tree, *Archaeosigillaria,* the largest and most complete of the terrestrial lycopod plants known from these rocks. The original of the restoration, taken from the Portage rocks at Naples and constituting a flattened trunk 11 feet long, has been remounted and cased, as has also the giant sea-weed *Nematophytum* from the Devonic rocks of Monroe, N. Y.

For the very extensive series of invertebrate fossils sufficient case room is not yet available and the necessary money has been provided for the construction of 37 additional cases which are designed to go entirely about the walls of the Paleontology Hall.

Attention has also been given to the vertebrate fossils. The Cohoes mastodon, a very celebrated skeleton and among the most complete known of the animal, has been set up by Mr Mirguet and in a manner much more effective than its original mounting. The Irish elk and the Asiatic elephant have also been remounted, the skull and tusk of the Ellenville mastodon set together and encased, the Harriman tusks and Monroe tusks put together. What is believed to be a fairly successful attempt to restore in natural proportions the extinct giant beaver of this State, Castoroides ohioensis, has been carried out and the model set up. It was modeled from measurements taken from the skull found at Clyde, N. Y., aided by more complete remains in the museum of Earlham College, Indiana. The workmanship is by Mr Marchand.

Restorations of the ancient Devonic fishes have been assembled in one case, recolored and effectively mounted.

A word should be said here in regard to the difficulty of preparing these exhibits in paleontology. The rocks of New York produce fossils which are almost exclusively of the invertebrate type and as a consequence the specimens are naturally small and rather inconspicuous except for certain noteworthy exceptions. The problem here is to present the small organisms to the public eye with the same effectiveness as if they were vertebrate objects of notable dimensions. It is needless to state that as natural objects each one is as momentous in its character and in the chain of life as though it attained the dimensions of the mammoth or the mastodon. Still, in the display of these small objects, all of a high degree of scientific interest, great thought and extreme care are necessary to make the presentation of them perfectly effective.

Digitized by Google

The remarks thus far made have especial reference only to the large south hall of the Museum. The efforts that have thus far been made herein toward installation have been supplemented by the accumulation and setting of the geological relief maps of which the Museum has now a considerable number and which it is hoped to supplement. The final determination of the arrangement of these relief maps has not yet been reached, but the walls of the halls afford reasonably favorable exposure for them and for such photographic illumination and similar decorative effect as may seem suitable.

Zoology. The cases for the Zoology Hall were not completed until the very end of the fiscal year, and as a consequence but little work has been possible in the matter of installing the extensive zoological collections. These cases number in all 43 and are divided into two series, one for the exhibition in zoology proper and the other for the exhibition in entomology, the two series of cases being of quite distinct types. In large measure the cases for the Zoology Hall are of conspicuous size and the installation in them of such groups as the large mammals will require much labor, artistic rendering and corresponding expense. From the old Museum was brought a limited number of small mounted groups, many of which have had to be repaired on account of the jolting received in moving. Among these also was one large group which has been entirely reset, and these few constitute all the mounted groups now in Zoology Hall. There remains, therefore, a very large amount of work to be done here, and if it is to be effectively done, it must be by the hands of expert workmen, who have not only ideas of scientific accuracy, but artistic conception and manual skill. Such men are not easy to find but the effort is being made to acquire the services of the highest grade in order that there may be no sacrifice of effectiveness in this hall. Meanwhile the installation of individual specimens of the higher mammalian and avian fauna has gone forward and at this time the case room available seems to be adequate for the immediate purposes of this division. It is, however, perfectly evident that this hall is now so full of cases that additions will be difficult and, if necessary, can not fail to close up the narrow aisles and aggravate the present obviously crowded condition. The members of the staff charged with this work are few in number and it will probably be necessary for a long time to come to go outside and employ the requisite expert assistants in ordering the zoological groups.

Digitized by Google

Archeology. The archeology section is to occupy the two mezzanine floors. Originally it was planned to restrict the archeological exhibit to the large mezzanine at the west of the building and to reserve the smaller mezzanine for the botanical collections. It seems, however, impracticable now to put together an effective exhibit in botany sufficient to fill the smaller mezzanine. The demands of the growing section of archeology for more room are imperious and the present plan contemplates assigning both mezzanines to this section and restricting botany, for the time being, to the space available in the separate compartment on the mezzanine floor at the east end of the building. The cases for the archeology section were released by the contractor only near the close of the fiscal year and these included only such as were embraced within the contract of George W. Cobb, jr. No provision had been made in that contract for the construction of the large group cases which are to contain the series of ethnological displays of the Six Nations. Since then plans have been undertaken which will lead to the construction of these cases to receive the groups for which the cost was contributed by the generosity of Mrs F. F. Thompson, and while these plans are now progressing, it will obviously be some time before these great cases are constructed and the exhibits completed.

Additional cases will be required, and reasonable provision has been made therefor, in order to put the smaller mezzanine in proper equipment for the reception of the archeological collections. In view of the uncertainty which prevailed as to the proper adaptation of the lesser mezzanine, the Cobb contract did not call for a sufficient number of cases to equip it suitably, and it is now hoped that the provision which has been made by the Board for additional cases may be adequate to put this room into proper order.

As a necessary consequence of these conditions the installation of the archeological collections, so far as it has gone (and some of the cases have been filled) is only temporary, for the construction of the new cases will require the removal and replacing of some cases already installed. Mention might properly be made, however, of certain work which has been done in the construction of the Indian graves in the cases prepared for them, the work on these having been effectively rendered and completed. This work has been carried out under the direction of Mr Parker by his assistants, Mr Clarke and Mr Lansing.

Digitized by Google

General. The Museum is still imperfectly equipped in office facilities and more especially in regard to suitable drawers for the keeping of the excess and duplicate storage collections of its material. We brought over from Geological Hall and State Hall many thousands of wooden drawers with their standards, for the purpose of affording necessary, even though dangerous, storage, and these are now standing in the corridors. In the basement of the building the machinery plant has been installed and the balance of the room there appropriated for the work of the Museum is given over to the storage of the large amount of material which it has been as yet impossible to open.

There have been some notable accessions to the collections purchased during the past year. These have been principally in the division of archeology which was the most severely injured by the Capitol fire. Of these recent additions those of leading importance are the collections of Indian materials brought together by R. D. Loveland, Watertown; Charles P. Oatman, Liverpool; Raymond C. Dann, Fairport; Alva S. Reed, Livonia; Frederick H. Crofoot, Sonyea; D. F. Thompson, Troy, and Otis M. Bigelow, Baldwinsville. This series of collections of Indian cultural relics constitutes the best of the Iroquois and pre-Iroquois materials now available in the State, and although further additions are always desirable, it is quite likely that they must be of very much less size and significance. To this list should be added the extensive collection of such materials made by Mr D. D. Luther, a member of the staff, from the Indian village in the town of Naples.

The Museum has also acquired by purchase the William D. Gebhard collection of fossils from the classical region of the Schoharie valley. This is the last of the great collections of fossils brought together by the Gebhards, through three generations, and the State Museum is fortunate in getting possession of it. An extensive collection of minerals from Orange county, made by the late Silas A. Young of Edenville, has also come into the possession of the Museum and makes an essential addition to the representation of New York minerals.

Full inventory of these collections will be given in the accession lists and made a part of this report, together with memoranda regarding smaller collections of various kinds and varying interest.

Orders have been given for the construction of a large relief map of the Finger Lakes region on the topographic scale of one mile to one inch. This is constructed for the purpose of showing

Digitized by Google

the detailed stratigraphy of that region as it has been worked out by the members of the Geological Survey. The map will cover the quadrangles of Canandaigua, Naples, Bath, Phelps, Penn Yan and Hammondsport. There is also under construction a model of Mormon hill, near Palmyra, celebrated for its historical associations as the place where the alleged " gold plates " of the Mormon bible were dug up and quite as interesting geologically as an illustration of a glacial drumlin, a topographic form which occurs abundantly in the region of the Lake Ontario plain.

Digitized by Google

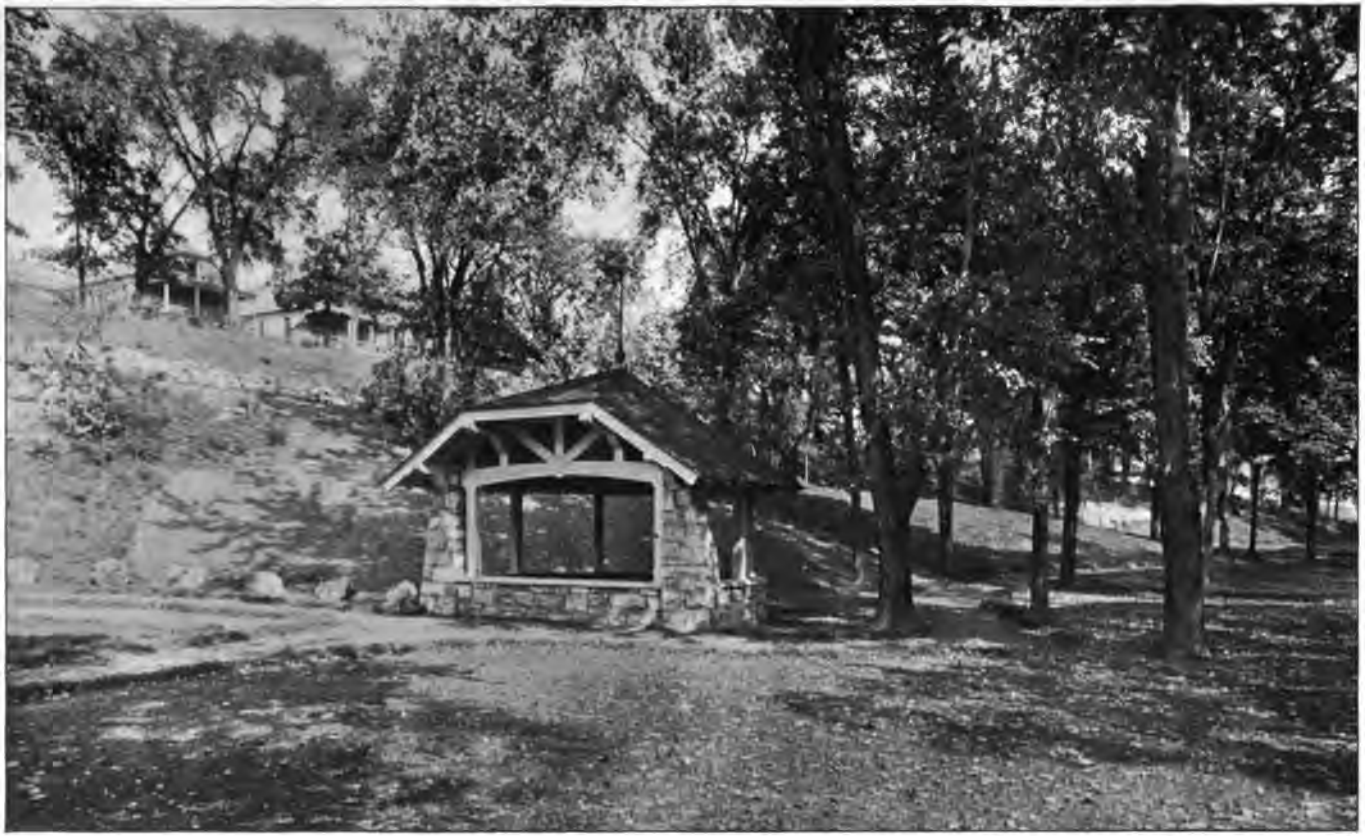
II

REPORT OF THE GEOLOGICAL SURVEY

CIVIC GEOLOGY

The mineral springs and the fault at Saratoga. On a later page reference will be made to the completion of the areal survey of the Saratoga quadrangle which covers the Mineral Springs basin. In the very successful operations made at Saratoga by the State Reservation Commission toward the rejuvenation of the exhausted springs, this office has taken a keen interest and has exercised such cooperation as has been in its control. In the execution of this work the commission has been successful to an unexpected degree in restoring the springs to their original virility, and in connection with the elaborate experimentation thereupon opportunity has been found to clear away the accumulations of rubbish and the tumble-down buildings which have long covered most of the escarpment of the celebrated *Saratoga fault*. The Saratoga fault has achieved a distinction which is perhaps quite out of proportion to its importance, and yet this fracture is a controlling influence upon the relief of the mineral water storage. The fault scarp stands as a rock cliff running through the village from the High Rock spring southward, gradually becoming a less conspicuous feature in the topography until it disappears in the vicinity of Congress Park or the United States hotel. The Saratoga fault has its heaviest throw far to the north of the village and in its course southward its escarpment lowers on its way through the length of the village until it is lost. It was formerly supposed that there was a direct continuation of this fault southward to Ballston where it influenced the Ballston mineral waters as it does those at Saratoga. The soil mantle covers all this area so deeply as to make it difficult to substantiate such an assumption. It has become clear, however, that the surface evidence of displacement terminates near Congress Park. In recent excavations made by the commission in preparation of the Spencer Trask memorial, to occupy this park, an opportunity was afforded of uncovering the rock surface at the south end of the fault where the displacement line is known to make a sharp turn to the west. The commission has, with fine appreciation of the geological interest attaching to this phenomenon, given instructions to have the probable course of the fault from this point uncovered where it crosses the street in the direction of the Ainsworth spring — the only water-bearing hole which has been put down west of the fault line.

Digitized by Google



SARATOGA FAULT
As exposed near the High Rock spring

Digitized by Google

Digitized by Google

SARATOGA FAULT
The escarpment at the High Rock spring

Digitized by Google

Digitized by Google

SARATOGA FAULT
The northern limb which has been cleared and parked

Digitized by Google

Digitized by Google

SARATOGA FAULT

The fault face, used as a dump for rubbish — a condition that will not long be tolerated

Digitized by Google

Digitized by Google

Of the several explanations offered for the existence of the heavily carbonated waters of Saratoga, one has assumed that it is along the fissure of the fault that the carbon dioxid has found its way from great depths within the crust of the earth.

Our present understanding of the geological origin of the mineral springs waters, briefly stated, is this: The region eastward of the fault is covered by a thick layer of impervious shale, which is very much broken up in the vicinity of the Hudson river. Where these shales are most disturbed and broken, the percolating meteoric waters have penetrated and have traveled along the dip of the underlying rock through the limestone beneath where as a result of secondary changes there taking place in the limestone, they have acquired carbon dioxid and when saturated with this gas have gained an increased solvent power which has enabled them to take up various soluble salts from the rocks through which they have passed. Traveling easterly they reach the fault fissure which they have been unable to traverse, and thus it happens that the springs derived through natural crevices or artificial holes in this basin, all lie on the east side of the fault line.[1] Whatever the future of the Saratoga mineral springs may be, and with the present and coming development of the science of hydrotherapy the outlook is most brilliant, Saratoga will always remain a place of high geological interest from the very fact of the relations of these waters to the rocks and to the fault line. It is therefore a matter of considerable public interest that the State commission should have brought out to its full effectiveness this fault cliff, even though the displacement is of a lesser order of magnitude. To increase public appreciation it might be well worth while to attach to the accessible face of the cliff, some placard or tablet which would explain the cause of the fissure and its influence upon the mineral waters. An eminent student of earthquake movements has suggested that it would be well worth while to attach a tablet not only to the face of the cliff but to the ground surface of the fault as well and have a precise leveling between fixed points on these two tablets so that it might be possible to determine any movement of the cliff up or down, that is to say, any reappearance of seismic or earthquake movements along this ancient line of weakness.

Stark's knob, Saratoga county. Stark's knob is a knoll of volcanic rock near the village of Schuylerville which, as its name

[1] The Ainsworth spring lying on the west of the fault, traversed it and derived its water from the east side.

Digitized by Google

indicates, has a definite historic association. It is the place where Captain John Stark established a little redoubt and effectually obstructed the movements of General Burgoyne during the battle of Saratoga. Its scientific interest, however, is quite as great, perhaps greater, than its historic. It has been described at length in the reports of the Geological Survey as a volcano or volcanic plug and as such is the only geological phenomenon of this kind known to occur in the State of New York. The question as to the origin of this plug, the stage at which the lavas penetrated the rock and the relation of the mass to all the surrounding geological terrane, has been much investigated and much discussed. There appears now to be very excellent reason, quite acceptable to those who have studied the phenomenon most closely, for assuming that this volcanic plug is not autochthonic, that is to say, is not now in the place where it originally appeared, but that in the great earth movements occurring in eastern New York during the time of the Taconic revolution, this volcanic mass was carried over on the crest of an earth wave from its original situs, possibly as far to the east as from the Connecticut valley in Vermont. This fact is not at the present time fully demonstrable but, as intimated, it seems a reasonable explanation to those who have studied the occurrence most closely. There are thus two elements of interest in this small and somewhat obscure topographic feature, of interest so extraordinary and unusual as to demand that some degree of public consideration be given to the preservation of this spot. Unfortunately some years ago the volcanic rock, which is a diabase, was thought to be available for highway construction, and the knoll or knob was leased for the purposes of producing road metal. The rock has decomposed so badly, however, that it has never well served any such purpose.

The writer has made an earnest effort to bring this spot under protection and control and there is a hope, perhaps not too remote, that the place may eventually become the property of the State under the custodianship of the State Museum. If this can be effected it will be a partial realization of a general public appeal made some years ago by the Director of the Museum for the preservation of objects of unique or noteworthy natural interest. This appeal met with many warm responses, but could be supported only by the activities of local societies or interested individuals, as no State money was available.

Digitized by Google

H. P. Cushing, photo

"Stark's Redoubt" as it appeared in 1910; from the southeast. Removal of rock has chiefly been from the south end; on the north it has been stripped though but little has been removed. The arrow points toward the slickensided surfaces

Digitized by Google

Digitized by Google

H. P. Cushing, photo, 1910

Glaciated surface of the "Cryptozoon Ledge" in the town of Greenfield, Saratoga county

Digitized by Google

Digitized by Google

H. P. Cushing, photo, 1910

Another view of the "Cryptozoon Ledge"

Digitized by Google

Digitized by Google

The "Cryptozoon ledge" in the town of Greenfield, Saratoga county. The geologists of the Survey have long been aware of the occurrence on the property now owned by Mrs Mabel A. Wesley, but generally known as the "Hoyt quarry," of a remarkable ledge of Cambric rocks exposing in most extraordinary fashion a reef of the fossil known as *Cryptozoon,* which is believed to be an algoid plant secreting a calcareous skeleton. This exposure is to be seen along the roadside from Saratoga Springs to Greenfield and the fact that the ledge has been smoothed down by glacial action renders it all the more conspicuous and interesting. These great circular Cryptozoon masses are often many feet in circumference, made up of concentric layers of algoid growths, and it is quite probable (indeed, it is so stated freely by geologists who have studied these ancient organisms in various parts of the world) that this exhibit is altogether unique. Especial interest attaches to these organisms from the fact that it is now thought that such reefs of algae or water plants, either marine or of fresh water, were present in the rocks of the Precambric and were among the first of known forms of life. This peculiar ledge of Cryptozoon is so out of the ordinary, so impressive to the student and even to the casual visitor, that an effort is now being made to bring it also under the control of the State as a public reservation. This is fully justified by the fact that the ledge is extraordinary, unique and teaches an interesting lesson which could well be explicated on the spot in case it can thus be brought under the control of the State Museum.

Mormon hill. Reference has been made to the production of a relief map of Mormon hill, in Wayne county near the village of Palmyra. This glacial drumlin or melon-shaped hill deposited by the melting ice sheet on its retreat to the north, is the spot where Joseph Smith, on a dark night in 1827, is alleged to have dug up the golden plates of the Book of Mormon. It is thus the Mecca of the Mormons and is visited by their distinguished members with frequency. In the history, therefore, of this State, it stands as a monument to a religious and civic enterprise which has now taken on an influential form, both of quality and circumstance; and it is well, therefore, that the place should be preserved. Doubtless the time will come when the disciples of this growing religious cult will themselves desire to possess and to protect the place; and should this ever happen, it is still to be remembered that its pre-eminent place as a factor in the history of the State is as one of the series of great glacial drumlins from a region in western New York

Digitized by Google

where they are better developed than probably in any other part of the world.

Indian Ladder Park. Geologists in many parts of the world will be interested in the announcement recently made of the gift to the State of New York as a public park of the "Indian Ladder" and its adjoining portions of the Helderberg mountains escarpment in Albany county, New York. Next, perhaps, to the Schoharie valley, the Helderbergs and the Indian Ladder have the most intimate and ancient association with the history of geology in this State and are really a classic ground in American geological science. Interesting not alone for its geology, as the original section of the "Helderberg formation" and its various subdivisions, with their profusion of organic remains, the Indian Ladder is equally commanding as a scenic feature. There is perhaps nothing just like it in origin and effectiveness. From the summit of the long sheer limestone cliff the eye commands the panorama of the conjoined Hudson and Mohawk valleys picturesquely spread out over a vast area bounded at the north by the foothills of the Adirondacks and at the northeast by the Taconic mountains and the Berkshires. And over this splendid picture generations of geologists have gazed, for the Helderbergs have been the Mecca of geologists for well-nigh a century.

The generous gift to the people of New York State comes from Mrs Emma Treadwell Thacher, widow of the late Hon. John Boyd Thacher, a distinguished statesman, historian and litterateur. Its more than 350 acres extends along the escarpment so far as to include all its most striking portions and the new reservation is essentially a geologic and scenic park.

Geological sketches from an old notebook. During the past year the Director received from Thomas T. Wierman, Esq., of Harrisburg, Pa., an old field notebook of the New York State Geological Survey, dated 1841. The book bears no evidence on its face of original ownership, but inquiry from Mr Wierman brought out the fact that the book had originally belonged to Richard C. Taylor, an English geologist of that period, whose notes and papers became the property of Captain John McCandles of Philadelphia and were later passed on to Mr John Fulton, a mining engineer, with whom Mr Wierman was employed in Bedford county, Pennsylvania, back in the '70s of the last century. Mr Wierman further states that Mr Fulton became a resident of Johnstown, Pa., a village which was wiped out by the great floods of 1889

Digitized by Google

SECTION ON EAST CANADA CREEK
Sketch from the notebook of R. C. Taylor, 1841

Digitized by Google

Digitized by Google

and that all the Taylor books and papers were lost with the exception of this, which finally came into his possession.

The book is a noteworthy record. Mr Taylor was an accomplished geologist and a fine field observer, as well as a sketch artist of no mean ability. The pages of the book are filled with carefully detailed geological sketches in water color, many of them of outcrops and of localities in this State which are no longer accessible. Mr Taylor had come to New York evidently for the purpose of putting himself in touch with the recently acquired results by the New York State geologists, and seems to have been particularly intimate with Mr Vanuxem, of the Third District. Evidently he was received with courtesy by his colleagues here and given this notebook, which bears the official stamp of the organization; but his field trips were made independently of the official geologists themselves and he traversed the State from the southwest corner to its eastern boundary and beyond. Some of Mr Taylor's sketches are of so great interest as to be worth bringing back to the public eye and to the public record of the New York Geological Survey, into which they have entered only in one or two instances; for it is to be noticed that Mr Vanuxem made references to Mr Taylor's Pennsylvania work in his annual report for 1837 and used several of his drawings in the Final Report on the Third District, of which may be mentioned the sketches of the cliffs on Cayuga lake and of the inclined strata in Howland's quarry near Union Springs. But Mr. Taylor's connection with the organization has never before been a matter of record and it may be well to give here the following brief sketch of his career.

He was born in England in 1789 and came to America in 1831. In his own country he had been a mining engineer and practical geologist, a member of the Geological Society of London and other learned institutions of Great Britain. His practice of geology was entirely economic, and in the development of the coal and iron industry, particularly of Wales, he gained for himself noteworthy distinction.

Upon his arrival in America he took up his residence in Philadelphia and shortly after was engaged in a survey of the coal fields of Tioga county, Pennsylvania, and subsequently in the southern coal fields in Dauphin county. Of so high order were these undertakings that he was frequently under professional engagement in other mineral districts of the United States. His great work, however, and that upon which his repute as a geologist rests, is

Digitized by Google

probably his well-known book "Statistics of Coal," published in Philadelphia in 1848. The book contained summaries of labors of a long life in connection with coal formation and coal production, and it was received both in England and here with the highest approval and with unstinted commendation.

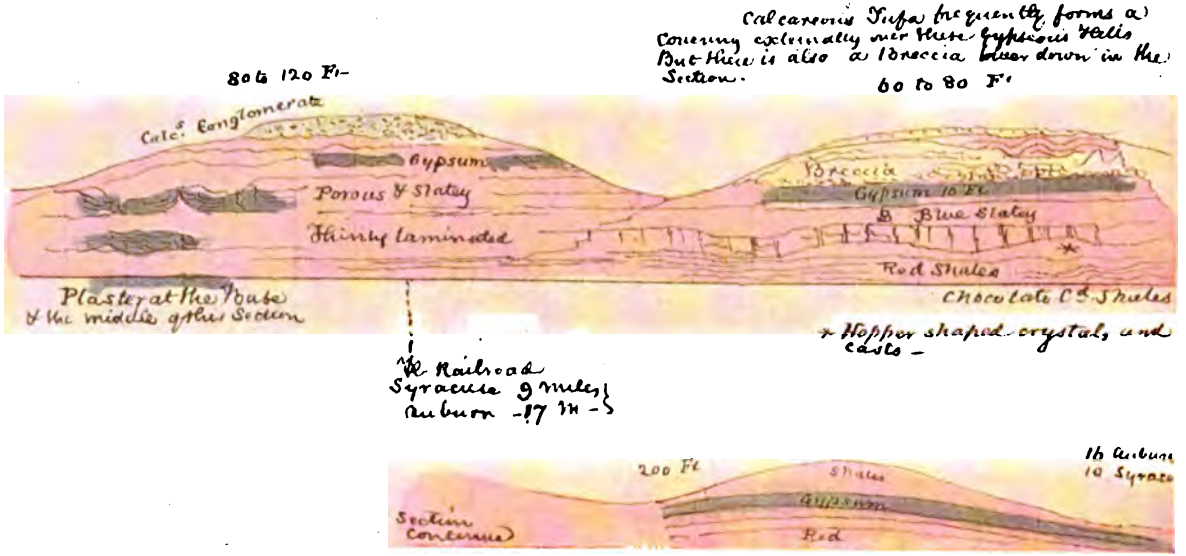
It was not exclusively to economic geology, however, that he devoted his interests, for his geological contributions show the versatility of his observations. He writes on the fossil marine plants of Mifflin county, on the existence of an ancient lake in Mifflin county, on the copper region of Cuba, on fossil plants in Dauphin county, on Indian mounds and earthworks, etc., etc.

Mr Taylor was a member of the American Philosophical Society and it is from the obituary notice of him read by Isaac Lea that the above memorandum has been largely taken. No mention, however, is made in any of the notices of his life that the writer has found, of his association with the New York State geologists or of his experience in the field of New York geology. As Mr Taylor was 52 years old when he came into the New York field, he was older than any of the four geologists engaged upon the survey and unquestionably had an experience in the field, especially, at least, in the field of economic geology, to which none of them could lay claim. Yet in spite of this fact, there is nothing in this notebook to indicate that his mind was especially fixed or his eye particularly keen to such development in New York. He seemed to be looking only for a knowledge of geological structure, to test the conclusions of the four geologists for his own personal and professional information and, so far as the writer is aware, he never expressed any public opinion or published any reference to his experiences and observations in the New York field.

Mr Taylor died in Philadelphia in 1851.

The time may come when it will seem well to reproduce, for the purpose of perfecting the record of the history of this survey, more of these sketches than are here given; but to indicate their character, their worth and their exactitude, the following pages carry a few of these, given, so far as seems practicable, in their original tints and with the original memoranda attached thereto.

Digitized by Google


Gypseous hills bordering the Railroad (S.) near Camillus
Calcareous Tufa frequently forms a covering externally over these Gypseous Hills But there is also a Breccia lower down in the Section.
80 to 120 Ft
60 to 80 Ft
Calc. Conglomerate
Gypsum
Porous & Slaty
Flinty laminated
Plaster at the Mine & the middle of the Section
Breccia
Gypsum 10 Ft
& Blue Slaty
Red Shales
Chocolate Col. Shales
* Hopper shaped crystals, and casts
The Railroad Syracuse 9 miles, Auburn 17 M
200 Ft
Shales
Gypsum
Red
Section Converse
Ith Auburn 10 Syracuse

GYPSEOUS HILLS NEAR CAMILLUS
Sketch from the notebook of R. C. Taylor, 1841

Digitized by Google

Digitized by Google

BOARD OF GEOGRAPHIC NAMES

The Legislature of 1913 provided for the institution of a State Board of Geographic Names, in the following law, which is chapter 187:

Section 1 Article 10 of chapter 23 of the Laws of 1909, entitled "An act in relation to executive officers, constituting chapter 18 of the Consolidated Laws," is hereby amended by adding, at the end thereof, a new section, to be known as section 110, and to read as follows:

§ 110 **Board of geographic names; powers and duties.** A State Board of Geographic Names is hereby created, to consist of five members, of which the Commissioner of Education and the State Geologist shall be ex officio members, and three of whom shall be appointed by the Governor to hold for terms of two, four and six years, to be designated by him when the appointments are made. Their successors shall be appointed by the Governor for terms of six years. Vacancies shall be filled by the Governor for the unexpired terms of the offices vacated. The State Geologist shall be the secretary and executive officer of such board. All of such members shall serve without compensation. The said board shall have power, and it shall be its duty:

1 To determine and establish the correct historical and etymological form of the place names in this State and to recommend the adoption of such correct forms for public use.

2 To determine the form and propriety of new place names proposed for general use, and no corporation, individual or community shall introduce such new place names without the consent and approval of this board.

3 To cooperate with the United States Board of Geographic Names and with the United States post office department in establishing a proper, correct and historically accurate form for all place names proposed as designations of new post offices.

§ 2 This act shall take effect immediately.

Acting under the authority given him by this law, Governor Sulzer appointed as members for the terms of two, four and six years, Arnold J. F. van Laer, Albany, Hugh P. Baker, Syracuse, Herman Leroy Fairchild, Rochester. This law carried no appropriation for the execution of its provisions, for clerical help or even for stationery; but as the work of the board has an obviously University function, it has seemed entirely proper, for the present, to carry on this work in connection with the other activities of this Department, awaiting the day when the Board of Geographic Names shall very properly become an organic part of the University.

Digitized by Google

There have been many and very excellent reasons for the creation of such a board and these were fully appreciated, both by the late Commissioner of Education and the committees of the Legislature before whom the proposition was brought, and expressed in the enactment. Local place names in the State have often gone astray from their original significance; very frequently names which have no propriety within the State of New York have been, of late years, added to its already somewhat incongruous assemblage; meaningless names, names which are combinations of euphonious, perhaps, but jejune syllables have been imposed upon the State, often at the instigation or by the connivance of public service corporations. New York has had its own troubles in its place names and there probably is not another equal area in America which is so bespangled with classical names without the remotest relationship to this country, as the Old Military Tract of central New York.

This board has been called upon to exercise its functions on several occasions in regard to the institution of new or proposed names, and this has been without solicitation or warning on its own part. It seems, however, quite likely that in the further rearrangement of place names in the State, it may be part of the duty of the board to direct attention to the existence of the law and to invite conformity therewith.

As a present evidence of the activity of the board and its purpose to do something more than pass upon applications made to it from whatever quarter, there is submitted herewith a glossary of the place names of three of the counties of the State, Albany, Schenectady and Rensselaer. The prosecution of such work as this, if carried out thoroughly, would form a useful series of documents bearing upon the historic development of settlements in the State and such work should be pursued even more completely than is here indicated. It will be understood that the present brief definition of the place names herewith attached is only a suggestion or a hint of the appropriate direction which some of the labors of the board may take.

THE PLACE NAMES OF ALBANY COUNTY

ADAMS STATION. Hamlet. Named for Nathaniel Adams, early settler. Also known as Adamsville. (Now *Delmar,* absurd misappropriation of well-known town name on border of Delaware and Maryland.)

ALBANY. County and city. Named in honor of James, Duke of York and Albany (1664), afterwards James II.

Digitized by Google

ALCOVE. Hamlet. Formerly Stephensville.

ALTAMONT. Hamlet (formerly Knowersville). Fancy name of no historical significance. *High mountain;* lies at base of Helderbergs.

AQUEDUCT. Hamlet. The Erie canal here crosses the Mohawk river.

AQUETUCK. Hamlet. *Ach-que-tuck,* Iroquois. Ach-que-tuck or Aquetuck was an early name for Coeymans Hollow. It is usually applied to the flats there but appears to be the *Hagguato* of the map of the New Hampshire Grants and the stream mentioned by Schoolcraft as *Hakitak,* below Coeymans. It may be derived from Ahque, *he leaves off,* and tuk, *a river;* i. e., *a river at a boundary* (Beauchamp).

AURANIA or URANIA. An early alternative name of Fort Orange.

BABCOCK CORNERS. Cognominal. Now Bethlehem Center.

BASIC creek. Thought to be Mahican; "may be a corruption of quassik, *a stone*" (Beauchamp).

BEACON island. Descriptive.

BEAR island. Descriptive.

BECKERS CORNERS. Hamlet. The Becker family were early settlers.

BEEREN island. The island of bears (Dutch). The Mahican name has a similar meaning (Beauchamp).

BERNE; BERNEVILLE; SOUTH BERNE. From Berne, Switzerland, native place of Jacob Weidman, one of the early settlers.

BETHLEHEM; BETHLEHEM CENTER. Suggesting the religious proclivities of the settlers.

BEVERWYCK. Original Dutch name of Albany.

BLACK creek. Flows over exposures of black shale.

BLOCKHOUSE creek. Early settlers built a blockhouse here.

BOGHT. Hamlet. Dutch = bend of the Mohawk river.

CABBAGE island. Descriptive.

CALLANAN CORNERS. Named for Henry Callanan, an early settler.

CASTLE island. Same as Van Rensselaer island. Fort Nassau was built on this island.

CEDAR HILL. Hamlet. Red cedar formerly covered the hills.

CHESTERVILLE. Hamlet. Named for Rev. John Chester of Albany. Now known as Westerlo.

CLARKSVILLE. Village. Named for Adam A. Clark, 1822.

COEYMANS. Town, village. Named for Barent Pieterse Coeymans, patentee.

COEYMANS HOLLOW. Hamlet on Hannacrois creek.

Digitized by Google

COHOES. Town, city. Mohawk = Ga-ha-oos, *canoe shooting over the falls.* "Cah-hoos or Ca-hoos, *a canoe falling,* as explained by the late Indian sachem, Brant." (Spafford)

COLONIE. Town. The Colony (Rensselaerwyck).

CONNERSVILLE. Cognominal.

COOKSBURG. Hamlet. Thomas B. Cook of Catskill, 1840, leading man in the Catskill and Canajoharie Railroad enterprise.

CRESCENT STATION. Hamlet. In the great bend of the Mohawk.

DELMAR. See ADAMS STATION.

DISBROWS. Hamlet in town of Westerlo. Name no longer in use.

DORMANSVILLE. Hamlet. Named for Daniel Dorman, first postmaster, 1832.

DUNNSVILLE. Hamlet. Named for Christopher Dunn, original owner.

DUNSBACK FERRY. Hamlet. Dunsback, early settler. Ferry over Mohawk.

EAST TOWNSHIP. Hamlet.

EIGHT-MILE creek. Descriptive.

ELDER creek. Descriptive.

ELSMERE. Modern name without appropriateness.

FECHTBERG. Hill in town of Berne. The name is said to have come from a dispute as to leadership among settlers, 1750.

FEURABUSH. Hamlet. Dutch: *vurenbosch* (pronounced *viirebosch*), fir-bush, or woods. (A. J. F. van Laer) Now known as Jerusalem, the name Feurabush being attached to the railroad station.

FLY creek. Dutch: *Vlaie,* meaning *a meadow.* Same as *Vly.*

"This word *vly,* in the records also written *vley* and *vleye,* is a puzzling word in the Dutch language. It is obsolete at present and its real meaning is unknown to me. The word seems to apply in nearly all cases to low, marshy land, or to salt meadows, and I suspect that it is nothing but a contraction of *valey,* valley, or low land. At all events I should say that the meaning was low land, rather than meadow. *Vlaie,* is probably a later corruption, which, as far as I remember, does not occur in the Dutch records." (A. J. F. van Laer)

FONT GROVE. Modern name.

FOXENKILL = Foxes stream.

FRENCH'S MILLS. Hamlet. Named for Abel French, miller.

FULLER. Hamlet. Named for Major John Fuller.

Digitized by Google

GIBBONSVILLE. Old village incorporated into West Troy, 1836. Now a part of Watervliet.

GLENMONT. Hamlet. Fancy name.

GREEN ISLAND. Village. Descriptive.

GROESBECK. Formerly a suburb of Albany, in the town of Bethlehem. Named for the Groesbeck family. Now obsolete and included in the southern part of the city.

GUILDERLAND. Township and village. Named from Gelderland, in the Netherlands.

GUILDERLAND CENTER and GUILDERLAND STATION.

HAMILTON or HAMILTONVILLE. "A town or settlement lately laid out in Albany county, New York, in the extensive township of Water Vliet, formerly called the *Glass Factory;* and has its present name in honor of that great patron of American manufactures, the late secretary of the Treasury of the United States of America. It lies 10 miles west of Albany, 2 miles from the Schenectady road; and is one of the most decisive efforts of private enterprise in the manufacturing line, as yet exhibited in the United States. The glass manufactory is now so well established and so happily situated for the supply of the northern and western people of the State of New York as well as Vermont and Canada, that it is to be expected that the proprietors will be amply rewarded for their great and expensive exertions. The glass is in good reputation. Here are two glass houses and various other buildings, curious hydraulic works to save manual labor by the help of machinery. A copious stream runs through the heart of the settlement which lies high; and being surrounded by pine plains, the air is highly salubrious. The great Schoharie road traverses the settlement. A spacious schoolhouse and a church of octagon form are soon to be erected."

"The enterprising proprietors of the *Glass* and other works in this thriving settlement, were incorporated by the Legislature of New York in the spring of 1797; by the name of 'The Hamilton Manufacturing Society,' which act has given spring to the works here; and authorizes a hope that American manufactures may not only subserve the interests of our county but that also of the proprietors." (Jedediah Morse's *Gazetteer,* 1798).

The settlement and enterprise became effaced by 1840 and the only local trace of it now remaining is to be found in the name "Hamilton Church" in Guilderland township.

Digitized by Google

HANNACROIS creek. Supposed to be from Dutch signifying a crowing cock. It is said that during a freshet a barn was carried down stream and perched upon an open door stood a cock crowing.

HAVERS island. In the Mohawk. From the Dutch: *haver,* oats. Same as VanSchaick's island.

HELDERBERG mountains. Variant derivations have been suggested for this Dutch word; *helder* = bright, *bergen,* mountains. *Helder,* a fort in Holland.

HILLHOUSE island. Cognominal.

HUNGER KILL. The local story says that wagon trains from Albany to Buffalo stopped here for refreshment.

HURSTVILLE. Hamlet. Named for William Hurst, 1861.

INDIAN FIELDS. Hamlet. Indians had planted fields and orchards.

IRELAND CORNERS. Hamlet. Named for Elias H. Ireland, 1832.

IRISH HILL (Berne). The first settlers were Scotch-Irish.

JANES CORNERS. Same as SOUTH BETHLEHEM. Elisha Janes kept tavern here.

JERUSALEM. Formerly Feurabush. This later application of an old name which has appeared only on recent maps is objectionable, in view of the well-established application of the word to a township in Yates county and to a village in Queens county.

KAIKOUT kill. Stream. Dutch: *kijkuit* = *look-out.* See Kykout (Rensselaer co.)

KARNER. Hamlet. Cognominal.

KEEFER CORNERS. Hamlet. Named for Balthus Keefer, 1791.

KENWOOD. Suburb of Albany. Named by Mayor Jared Rathbone, Albany, after a Scotch place of his acquaintance.

KIMMEY'S CORNERS. Cognominal.

KNOWERSVILLE. Now ALTAMONT.

KNOX. Township and village. Named for John Knox by the Scotch settlers.

KRUM kill. Stream. Would seem to be from the Dutch *krom* or *kromme,* crooked.

LAMBS CORNERS. Hamlet. Named for Jehial Lamb, early settler.

LISHA KILL. Hamlet and stream. Name of Indian buried here.

LOUDONVILLE. Hamlet; on Loudon road, 3 miles from Albany. Named in memory of Lord Loudon, general of the English forces in barracks at Albany, 1756.

MCKOWNSVILLE. Hamlet. Named for the McKown family, early settlers.

Digitized by Google

MARSH island. Descriptive.

MEADOWDALE. Hamlet. Fancy name, modern.

MEDUSA. Hamlet. Modern intrusion. Originally Hall's Mills, named for Uriah Hall, 1783.

MENANDS (properly MENAND). Hamlet. Named for Louis Menand, a Frenchman and first settler.

MORE'S CORNERS.

NEW SALEM. Hamlet. Named in 1830. An expression of the piety of the early settlers.

NEW SCOTLAND. Township, village. There were many Scotch families among the early settlers.

NEWTONVILLE. Hamlet. Named for John M. Newton.

NORMANS kill. Stream. A Hollander, Albert Andriessen Bradt, from Frederikstad, Norway, surnamed the Norman, settled at mouth of creek about 1630.

NORMANSVILLE. See NORMANS KILL. Early name UPPER HOLLOW.

ONISKETHAU. Hamlet. See ONISKETHAU creek.

ONISKETHAU creek. The old Indian name of the region *O-nits-quat-haa,* deeded in 1685 to Teunis Slingerland and Johannes Appel. "It is said to have been an early name for Coeymans, meaning *cornfields.*" (Beauchamp)

PATROON creek. Named after the Patroon of Rensselaerswyck.

PATROON island. The same.

PEORIA. Hamlet. Borrowed name.

PORT SCHUYLER. Old hamlet incorporated into West Troy 1836. Now part of the city of Watervliet.

POTTER HOLLOW. Hamlet. The Potter family were early settlers.

PRESTON HOLLOW. Named for Dr Samuel Preston, 1798.

RAVENA. Modern name. It has no local significance.

REIDVILLE. Village. Named for George Reid, Scotch immigrant.

RENSSELAERVILLE. Township, village. Named for General Stephen Van Rensselaer, patroon of Rensselaerswyck.

RENSSELAER lake. The same.

SELKIRK. Hamlet. The first settlers were the Selkirk families of Scotch descent.

SHAKERS. Hamlet. The Shakers settled here in 1776.

SLINGERLANDS. Village. Named for descendants of John A. Slingerland.

SOUTH BETHLEHEM. See BETHLEHEM and JANES CORNERS.

SPENCERVILLE. Cognominal. Same as West Albany.

STEPHENSVILLE. Hamlet. Named for Archibald Stephens, miller.

STONY HILL. Hamlet. Descriptive.

Digitized by Google

SWITZKILL. Stream. There were many Swiss settlers in the town of Berne.

TEN-MILE creek. Descriptive.

THOMPSON lake. Named for John and William Thompson.

TIVOLI HOLLOW. Early hamlet now included in the northern part of the city of Albany.

TOWNHOUSE CORNERS. Hamlet. Descriptive.

UNIONVILLE. Hamlet. A "Union" church is located here. Originally UNION CHURCH.

UPPER HOLLOW. Early name for Normansville.

VAN LEUVEN'S CORNERS. Hamlet. Named for Isaac Van Leuven, early settler.

VAN SCHAICKS island. In the Mohawk. Cognominal.

VAN WIE'S POINT. On Hudson river. Named for Jan Van Wie.

VLAUMANS kill. Stream. Cognominal.

VOORHEESVILLE. Hamlet. Named for Alonzo B. Voorhees, 1862.

WARNER lake. Named for Johannes and Christopher Warner.

WATERVLIET. City. Dutch; *water*=water, *vliet*, stream, course. Former name West Troy, which, in 1836, was incorporated of the villages or hamlets of Gibbonsville, Watervliet and Port Schuyler.

WEMPLE. Hamlet. From a pioneer family.

WESTERLO. Township and village. Named for Rev. Eilardus Westerlo, a Dutch clergyman in Albany, 1760. Formerly known as Chesterville.

WESTERLO island.

WEST TOWNSHIP. Hamlet.

WEST TROY. Now a part of Watervliet.

WILLEMSTADT. The name given to Albany in 1673 in honor of Willem (William) III, of Orange, later king of England.

WILLIAMSBURGH. Hamlet. Now Connersville.

WOLF creek. Descriptive.

WOLF HILL. Hamlet.

THE PLACE NAMES OF RENSSELAER COUNTY

ALBIA. Suburb of Troy.

ALPS. Hamlet. In the hilly eastern part of the county.

AVERILL PARK. Hamlet. Named from old and prominent family in the town of Sand Lake.

BABCOCK pond. Named for John Babcock.

BALD mountain. Descriptive.

Digitized by Google

BARBERVILLE. Hamlet. Cognominal.

BATH. Named from supposed medicinal qualities of a spring near it. Now included in city of Rensselaer and name abandoned.

BERLIN. Township, hamlet.

BERLIN CENTER. See BERLIN.

BLACK brook. Takes its name from the black shales over which it flows.

BLACK river. Same as above.

BOYNTONVILLE. Village. Cognominal.

BRAINARD STATION. Hamlet. Named for David Brainard, missionary to the Indians here.

BROOKVIEW. Hamlet. Modern name; formerly Schodack Center.

BRUNSWICK. Township; hamlet. Said to have been settled by a colony of Germans. Among early settlers was a family by the name of Braunschweiger.

BURDEN lake. Cognominal.

BUSKIRK'S BRIDGE. Village, on Hoosick river. Named for Van Buskirk family, early settlers.

CAMPBELL island. Cognominal.

CASTLETON. Village. Named from Castle hill on which stood an Indian fortification.

CENTER BRUNSWICK. See BRUNSWICK.

CHURCH HOLLOW. Named from the Church family, early settlers.

CLUM'S CORNERS. Hamlet. Named for O. Clum, blacksmith.

Cow island.

COOPER pond. Cognominal.

CRANBERRY pond. Descriptive.

CROPSEYVILLE. Hamlet. Named for Valentine Cropsey, early settler.

DEEP kill. Descriptive.

DEFREESTVILLE. Hamlet. Named for the early settlers DeForeest; also spelled DeForest, DeFreest and DeFriest.

DUNHAM HOLLOW. Named for Isaac Dunham, settler, 1800.

DILL creek. This may have been a family name, or perhaps derived from the presence of dill along its banks.

DWAAS kill. Stream connecting the Hoosick and Hudson rivers, its current varying with freshet. "This is probably a corruption of *Dwars kill,* or cross creek, a stream connecting two others, just as a *dwars straat* means a cross street. *Dwaas=foolish;* hence, I suppose, the attempt to explain the name as "of two minds," a stream "flowing both ways." (A. J. F. van Laer)

Digitized by Google

EAGLE BRIDGE. Village at the bridge over Hoosick river. Patriotic.

EAGLE MILLS (MILLVILLE). Village. Valuable water power on Poestenkill.

EAST GRAFTON. See Grafton.

EAST POESTENKILL. Hamlet. See POESTENKILL.

FONDA hill. Named for John Fonda, 1750.

FOX HOLLOW. Name may be derived from Levit Fox, early settler, or may be descriptive.

GARFIELD. Hamlet. Modern and patriotic; originally South Stephentown.

GLASSHOUSE. Extensive glass works.

GLASS lake.

GRAFTON. Township and hamlet. Named from Grafton, Vt.

GRANT HOLLOW. Hamlet. Grant-Ferris Co. operated an agricultural implements factory here.

GRAVEL pond. Descriptive.

GREENBUSH. Township and village. *Greene bosch,* from the pine woods adjoining. Now part of the city of Rensselaer.

HANFORD pond. Cognominal.

HAYNERVILLE. Hamlet. Named for the Hayner families, early settlers.

HAYNERS pond. Cognominal.

HICKS pond. Given as *Hacks pond* on old map.

HILLS HOLLOW.

HOAG CORNERS. Named for W. B. Hoag, early settler.

HOAG'S pond. Named for Jonathan Hoag who constructed dam and formed pond.

HOOSICK. Township, village, river. Mohawk, *stony place* (Ruttenber). Algonquin, *along the kettle* (Beauchamp).
HOOSICK FALLS, HOOSICK JUNCTION, WEST HOOSICK and NORTH HOOSICK, all take name from the river.

IVES CORNERS. Hamlet. Named for Ives family, early settlers.

JOHNSONVILLE. Hamlet. Named for William Johnson, early proprietor, 1800.

KENDALL pond. Named for David Kendall, early settler.

KINDERHOOK creek. A Dutch name signifying "Children's Point." Name belongs properly to Columbia county.

KYKOUT hill. From Dutch *Kykuyt* or *Kijkuit* (modern spelling) = *lookout.*

LANSINGBURGH. Town, village (part of Troy). Named for and laid out in 1771 by Abraham Jacob Lansingh as the City of

Digitized by Google

Lansinghburgh. In its early history commonly known as New City in contrast to Albany, the "Old City."

LITTLE SCHODACK island. See SCHODACK.

LONG pond. Descriptive.

LOWER SCHODACK island. See SCHODACK.

LYONS pond. Cognominal.

MASTENS CORNERS. Hamlet. Named for the Masten family, storekeepers.

MELROSE. Hamlet. Probably Scotch.

MESHODAC PEAK. Indian = *mishadchu, great mountain* (Beauchamp).

MILLER CORNERS. Hamlet. Named for George Miller, storekeeper, 1840.

MILLVILLE. Alternative name for Eagle Mills.

MOLLS island. Named for the Molls family.

MOLLS PLAAT. Named for the Molls family.

MOON hill. Named for the family of J. S. Moon.

MOORDENER kill. Stream. Refers to an early battle on its banks between settlers and robbers. "Moordener is a corruption of Moordenaer or Moordenaar = murderer." (A. J. F. van Laer)

MUITZES kill. Stream. The story is that a Dutch female with high hat lost it in the stream and cried out, "Di muitz is in de Kil." "*Muitzes* may be a corruption of *Mutzen* (pl. of *Muts* = woman's lace cap or man's woolen or fur cap), but the story sounds foolish. More likely, *Muitzes* is a corruption of *Muizen* –mice." (A. J. F. van Laer)

NASSAU. Township, village. Named from old Nassau; originally Philipstown.

NORTH NASSAU, EAST NASSAU, NASSAU pond.

NEPIMORE creek.

NEWCOMB POND. Named for Daniel Newcomb, 1790.

NORTH GREENBUSH. See GREENBUSH.

ODELL hill. Named for Simeon Odell, 1790.

PAPSCANIE island. Abbreviated from the name of the original owner, Papsickenekas or Paep-Sikenekomtas.

PATTERSONS CORNERS. Hamlet. Named from early settlers.

PECKHAM pond. Named for early pioneer who lived near it.

PETERSBURG. Township, village. Named for Peter Simmons, 1791.

NORTH PETERSBURG.

PETERSBURG JUNCTION.

PIKE hill. A companion name to Pike pond.

Digitized by Google

PIKE pond. Descriptive.

PITTSTOWN. Township, hamlet.

PIXTAWAY island.

PLATTSTOWN. Hamlet. Originally Platstown from Peter Plate, innkeeper. Better known as *Tamarac*.

POESTENKILL. Township and hamlet. Named for Jan Barentsen Wemp, nicknamed Poest. "*Poest* means a cowherd." (A. J. F. van Laer)

POPLAR hill and POPLAR island.

POTTER hill. Hamlet. A man named Potter was killed here by accident.

PROSSER HOLLOW. Stream. Named for Ichabod Prosser, early settler.

QUACKEN kill. "Probably from Quack, or Kwak (pl. Quacken, Kwakken), a heron (Ardea nycticorax). Kwakken also means 'to croak,' but if the kill was full of frogs, it would more likely be called Kikoorschen kill than Quacken kill." (A. J. F. van Laer)

RAYMERTOWN. Hamlet. Named for Raymer family, early settlers.

RED pond. Descriptive; colored by soil.

REICHARD pond. From Reichard family, early settlers.

RENSSELAER. City, county. Taken from Albany county in 1791 and named for the Patroon of Rensselaerswyck.

REYNOLDS. Hamlet. Cognominal.

ROCK HOLLOW. Hamlet. One of the gorges of Quacken kill.

ROUND pond. Descriptive.

SAND LAKE. Township, hamlet, lake. Descriptive.

SCHAGHTICOKE. Township, village. Named for the Schaghticoke or Skaachkook tribe of Indians.

SCHAGHTICOKE hill.

SCHAGHTICOKE JUNCTION.

SCHERMERHORN island. Named for Cornelius Schermerhorn.

SCHODACK. Township. Indian *Skootag*, fire, *ack*, place; "fireplace of the nation." Council seat of the Mahicans in this town.

SCHODACK CENTER. Hamlet = BROOKVIEW; SCHODACK LANDING; SOUTH SCHODACK; Hamlets.

EAST SCHODACK. Hamlet.

SHAD island. Descriptive.

SHAVER pond.

SHINGLE HOLLOW. Stream. Recalls a shingle mill.

SLITERS. Village. Named for Calvin Sliter.

Digitized by Google

SNAKE hill. Descriptive.

SOUTH BERLIN. Hamlet. See BERLIN.

SPEIGLETOWN. Hamlet. Named for the Vanderspeigle families, early settlers. "Vanderspeigle is probably a corruption of the well-known Dutch family name of van de Spiegel. Cf. Lawrens Pieter van de Spiegel, a famous Dutch statesman, about the time of the French revolution, for whom a street in Amsterdam is named." (A. J. F. van Laer)

STAATS island. Named for Barent Staats.

STEPHENTOWN. Township, hamlet. Named for Stephen Van Rensselaer, Patroon, 1784.

STEPHENTOWN CENTER. Hamlet (formerly Mechanicsville).

WEST STEPHENTOWN, SOUTH STEPHENTOWN and NORTH STEPHENTOWN. Hamlets.

STILLMAN VILLAGE. Hamlet. Cognominal.

SUNKAUISSIA creek. Sank-an-is-sick, a branch of the Tomhannock. Root may be sonkin, *to grow up like a plant.* (Beauchamp).

SWEET MILK creek.

TACONIC mountains. Indian name. Beauchamp gives Tagh-ka-nick, *water enough.* Zeisberger has Tach-an-ni-ke, *full of timber.*

TACKAWASICK pond and creek. (= Tsat-sa-was-sa and Sas-sa-was-sa).

The name may refer to a stone mortar (Beauchamp).

TIASHOKE. Hamlet. (Ty-o-shoke). Iroquois, "meeting of waters" (Beauchamp).

TIERKEN kill. Dutch=noisy creek. "The derivation from the verb *tieren,* to make a noise, does not account for the *k* and seems impossible, as *tieren* is used only in connection with people. A more likely derivation is from Tierk, or Tjerk, the Frisian form for Dirck, the given name of some early settler." (A. J. F. van Laer)

TOMHANNOCK. Hamlet and creek. Mohawk=a flooded river (Beauchamp).

TROY. City. Originally Van Der Leyden and Van Der Leyden's Ferry. "Changed in 1789 into the more classic name of Troy." It contains two hills, Mt Olympus and Mt Ida.

UPPER SCHODACK island. See SCHODACK.

VALLEY FALLS. Village, on Hoosick river.

VOSBURGH pond. Cognominal.

WALLOOMSAC. River and hamlet. Variously written, of Indian derivation.

Digitized by Google

WEST SAND LAKE. See SAND LAKE.
WHITE LILY pond. Descriptive.
WHITE ROCK mountain.
WYNANTSKILL. Village and stream. Named for Wynant Gerritse Vanderpoel, 1674.

THE PLACE NAMES OF SCHENECTADY COUNTY

AALPLAATS. Village and stream. Dutch, *a place for eels.* Now corrupted to Alplaus. "Given as Aelplaats in Burr's atlas of 1829, Aelplatts and Alplatts on map of 1856. Though *plaats,* in Holland, by the illiterate, is often pronounced *plaus,* it would seem as if Alplaus might be a corruption of *Aalplas* = eel pond." (A. J. F. van Laer)

ADAMS KILLETYE. Stream. From Adam Mull, taken prisoner by the Indians when drinking from it. "*Killetye,* corruption of *Killetje* = little kill (old spelling *Killetie,* though doubtless pronounced Killetje and not Killet*ee*)." (A. J. F. van Laer)

ALPLAUS. Modern corruption of Aalplaats.

AQUEDUCT. Hamlet. Canal crosses Mohawk.

BINNE kill. Stream. "Inner river." A short diverted part of the Mohawk south of Van Slyck island.

BONNY BROOK. Named by the Scotch settlers.

BRAMANS CORNERS. Hamlet. Named for Dr Joseph Braman, 1840.

CHUCTENUNDA. Stream. Chaugh-ta-noon-da = *stony houses* or *stony places.*

COOKSBOROUGH. Hamlet. Named for the Vandercook (Van der Koek?) families.

CRABBE kill. Stream. Cognominal.

DELANSON. Village. Present name of Quaker Street. Combination of "Delaware and Hudson."

DUANESBURG. Town, village. Named for James Duane who settled here in 1765.

EAST GLENVILLE. Hamlet. See GLENVILLE.

EATON CORNERS. Hamlet.

FEATHERSTONHAUGH lake. Named for the Featherstonhaugh family. Now improperly written Featherstone lake.

GIFFORDS. Hamlet. Named for J. Gifford, hotel keeper.

GLENVILLE. Township and village. Named for Sanders Leendertse Glen, patentee, 1820.

GREENS CORNERS. Hamlet. Named for the early settlers.

Digitized by Google

HIGH MILLS. Hamlet. Old milling settlement deriving its name from falls in the Alplaus known as High falls.

HOFFMAN'S FERRY. Named for John Hoffman, 1835. Now HOFFMAN. Originally VEDDER'S FERRY, from Harmanus Vedder, 1790.

JAN WEMPS creek. Jan Barentsen Wemp was the ancestor of the Wemp family. Name appears on some maps as Van Wemps creek.

KELLEY'S STATION. Hamlet. Named for Andrew Kelley.

MARIAVILLE. Hamlet. Named for a daughter of James Duane.

MOHAWKVILLE. Hamlet.

NISKAYUNA. Township, village. Con-nes-ti-gu-ne or Nis-ti-goo-ne, *cornflats.*

NISKAYUNA pool. Name recently introduced, with approval of Board of Geographic Names, for a body of water impounded by barge canal construction. Replaces "Peck Lake," not approved.

PATTERSONVILLE. Village. Named for W. H. Patterson, hotel keeper.

PLOTTER kill. Stream. "Plotter kill is probably a corruption of Platte kill, which occurs also in Ulster county. Platte kill = *flat creek,* seems a strange name. *Het platte land* is the term applied in Holland to the country districts, in contradistinction to the cities, and in a country which is mostly flat, is self-explanatory. But why a kill should be called *plat* I do not know." (A. J. F. van Laer)

POENTICS kill. Stream. "This may be a corruption of Poenties kill. Poentie (or Poentje) was the nickname given to both Teunis Cornelissen Van Vechten and Teunis Dircksen Van Vechten (see Van Rensselaer Bowier MSS, p. 815, 819). The meaning of the word *poentje* is unknown to me. *Poent* is Middle Dutch spelling for modern *punt* = point. *Poentje* is the diminutive form. There is also a word *poenter* = assessor, so that poentje may be either a nickname for a person with a pointed face, nose or chin, or else be the real surname of the Van Vechtens, derived from some ancestor who held the office of assessor." (A. J. F. van Laer)

PRINCETOWN. Named for John Prince of Schenectady, member of Assembly.

QUAKER STREET. Village. Quakers settled here in 1790 and made purchases of land. Now Delanson.

Digitized by Google

REESEVILLE. Named for an early settler. Now a part of Scotia.

ROTTERDAM. Township and village. Named from Rotterdam, Holland, on account of lowlands.

RYNEX CORNERS. Hamlet. Several members of Rynex family settled in this vicinity.

SANDERS lake. Named for Sanders family.

SANDSEA kill (formerly, ZANTZEE kill). Stream. "*Zantzee* (better *Zandzee*, or else *Santsee*) is a familiar Dutch expression for *sand desert*." (A. J. F. van Laer)

SCHENECTADY. County and city. Schagh-nac-taa-dagh, *beyond the pine plains.*

SCOTIA. Village. The ancient name of Scotland. The patentee, Sanders Leendertse Glen, was a Scotchman.

TOWN HOUSE CORNERS. Hamlet. The town's business was transacted here.

VAN SLYCKS island. Named for Jacques Van Slyck, 1662.

VERF kill. Stream. Dutch = *paint creek*. "Given in Burr's atlas of 1829 as Vert kill. This, however, has no significance as most of the Dutch names in that atlas are misspelled." (A. J. F. van Laer)

WEST GLENVILLE. See GLENVILLE.

AREAL GEOLOGY

In previous annual reports statements have been regularly given in regard to the progress made in the completion of the great geologic map of the State on the topographic base, scale of one mile to one inch. It may be broadly stated that the quadrangles which have been surveyed and fully reported upon, or upon which work is under way, now number approximately 40, although this is but a small percentage of the total number of quadrangles of the State already surveyed by the United States Geological Survey, in cooperation with the State Engineer and Surveyor. The execution of the geological work is of a kind which must of necessity progress very slowly and with every possible attention to detail. The progress of the work, however, has at no time been interrupted and at the time of writing this report there are now in press final reports on the following areas, accompanied by detailed geologic maps on the topographic base:

The Attica and Depew quadrangles

Published together as a single map with descriptive text, by Mr Luther.

Digitized by Google

The Saratoga and Schuylerville quadrangles

Also published together in one report with full descriptive details and discussion of the various important interests pertaining to the Saratoga Mineral Springs basin, by Professor Cushing and Doctor Ruedemann.

The North Creek quadrangle

Lying in the eastern Adirondack region, the report and map of which have been prepared by Professor Miller.

The Syracuse quadrangle

and its accompanying text, by Professor Hopkins.

In addition to these reports, there is also a bulletin on the Geological History of New York by Professor Miller, which relates especially to the physical development of this State. All these publications will presently be ready for distribution.

Central and western New York. In this region Mr Luther has continued the long series of field surveys upon which he has been engaged for nearly twenty years, and during the season of 1913 covered the quadrangles of Olcott and Lockport and that part of the Tonawanda-Wilson quadrangles which lies east of the east line of the map prepared and published some years ago in connection with Professor Grabau's bulletin on the Geology of Niagara Falls. Mr Luther's reports on the quadrangles mentioned are now essentially prepared and will soon be ready for publication.

Northern New York. Professor Miller began the survey of the *Blue Mountain* quadrangle during the summer of 1913. Most of the time was spent in making a detailed study of approximately one-third of the area in the vincinity of Long Lake and Blue Mountain Lake villages. As most of the quadrangle has not been examined and no laboratory work on the rocks yet been undertaken, only certain more evident results of the field work so far executed can be here presented.

Grenville series. The Grenville rocks are but slightly represented. Their only important development, where free from closely involved igneous rocks, is in Blue Mountain lake and immediate vicinity. With slight exceptions, all the islands of the lake consist of Grenville limestone and hornblende-garnet gneiss together with smaller amounts of quartzite and various well-banded gneisses. Outcrops are usually large and excellent. Similar outcrops occur on the lake shores except on the north, and no doubt the bottom of the lake consists almost wholly of such Grenville strata.

Syenite-granite gneiss series. Rocks of the syenite-granite gneiss series constitute most of the area studied. No very basic phases

Digitized by Google

of the syenite were noted, the usual rock being the greenish grey, quartzose variety so well known throughout the Adirondacks. There are many fine exposures as, for example, on Blue mountain, Owl's Head mountain and in the vicinity of Long Lake village, particularly in the large stone quarry alongside the road 1½ miles southwest of the village. With increasing quartz content this rock passes into a granitic syenite which frequently shows a pinkish color. The granitic syenite in turn grades into true granite gneisses which are nearly always pink or red. Many small and large Grenville gneiss bands or inclusions occur parallel to the foliation in all facies of the syenite-granite series. Frequently these rocks show rather rapid changes in color and composition parallel to the foliation, though not the slightest evidence that one of these rock types cuts another has yet been found. Rather there is much evidence to show that the different facies really grade into each other and are only variations of the same intrusive body. Though at times the porphyritic texture is somewhat developed, no mappable areas of granite or syenite porphyry were found.

Mixed gneiss series. There are two considerable areas of syenite-granite and Grenville mixed gneisses. One of these occupies several square miles just south of Blue Mountain and Eagle lakes and the other some 8 or 10 square miles along the northern border of the quadrangle. As usual, in areas previously reported by the writer, these rocks consist of Grenville strata shot through by and closely involved with syenite or granite. Often wide bands of Grenville are plainly visible while more rarely the Grenville has been more or less assimilated by the intruding magma.

Gabbro. Several gabbro stocks or dikes of the usual sort with associated amphibolite have been found. The largest, occupying three-fourths of a square mile, is crossed by the main road 4 miles east of Long Lake village.

Diabase. Two fine diabase dikes occur on the eastern shore of Long lake, respectively one-half mile and 1 mile north of Long Lake village. One dike has a width of 40 feet and both show sharp contacts and clear-cut branches from the main masses. They strike north 30° east.

Faults. It is quite evident that the western portion of the Blue Mountain quadrangle lies west of the region of extreme faulting in the Adirondacks. Good evidence for but one fault was found and this line of fracture has determined the Raquette river channel across the corner of the quadrangle. Thus the remarkably straight

Digitized by Google

northeast-southwest strike of this channel is accounted for. Nothing very positive can be said regarding the amount of displacement and date of this fracture but its presence is demonstrated by fine crushed and broken rock zones at Buttermilk falls and several places in the ledges along the shores of the lake.

Glaciation. A number of good glacial striae were observed especially near Long Lake village and toward the western base of Blue mountain. These bear from south 30° to 50° west, thus harmonizing with other observations in the interior Adirondack region. Much glacial drift has been deposited, particularly over the lowlands, but there is no good evidence for ice erosion other than the removal of superficial loose or decomposed materials.

Brier Hill and Ogdensburg quadrangles. Professor Cushing was engaged for part of the summer of 1913 in the Brier Hill and Ogdensburg quadrangles and reports that, so far as his observations have extended, the Precambric rocks are of considerable interest. There are long, narrow tongues of porphyritic syenite cutting the Grenville rocks and in parallelism with their structure. It is suggested that they are of the nature of huge dikes, but if this is the case the parent body of syenite from which they sprung nowhere appears and must lie to the south on the Gouverneur sheet. There is much amphibolite and interbedded Grenville sediments cut by the porphyritic syenite. Part of this amphibolite, however, into which the porphyritic syenite appears to grade, is evidently igneous, yet so far it has proved impossible to distinguish certainly the two in the field.

The Paleozoic section is well shown on these two quadrangles and is of much interest. The Potsdam sandstone is thin and of unequal thickness owing to the irregularity of the surface on which it was deposited. It is quite like the Potsdam of the Alexandria Bay and Theresa region described in Museum Bulletin 145. The overlying Theresa formation has greatly thickened and in its upper portion carries a massive 20 foot sandstone which is prominent all across this district and, according to Professor Chadwick, is continuous into the Canton quadrangle. The horizon is fossiliferous but until a definite examination of the fossils has been made it is not practicable to say whether this sandstone and the overlying beds are positively of Theresa or whether they may be of the age of the Tribes Hill formation. The overlying Beekmantown formation has a thickness of about 100 feet, with no summit shown. It is highly fossiliferous and these fossils indicate that the base

Digitized by Google

of the formation here is comparable with the middle of subdivision D of the Champlain section, that is, that division D and C of that section and the lower part of D, are lacking here and that Beekmantown deposition at the west of the Adirondacks began correspondingly later than in the Champlain valley.

Canton quadrangle. Mr Martin, who has been occupied with the Precambric rocks of this quadrangle, reports as follows:

The *Grenville formations* and the later intrusives are about equally abundant in the area examined. Nothing older than Grenville was discovered, for these rocks everywhere rest upon later igneous masses. Their total thickness is not demonstrably greater than 2 miles. Of the Grenville sediments, the limestones, in varying degrees of purity, are perhaps the most abundant; sometimes they are made up of pure carbonate of lime, but as a rule there is a prominent admixture of silicates, actinolite, coccolite, phlogopite and other minerals. Transitions through quartz-mesh varieties to thin-bedded quartz-schists are often observed.

Garnet-gneiss, with garnet-free varieties, is strongly developed in the southeastern part of the quadrangle, but elsewhere it occurs only in thin layers. These rocks are associated with limestones and rusty gneisses, and the total thickness is not far from 3500 feet. The series has been injected by later intrusives of both gabbroic or gabbro-dioritic and granitic composition, and the whole doubly folded back upon itself into an immense isoclinal sigmoid, now beveled by the surface of erosion.

Silicious gneisses, occurring chiefly in the western part of the sheet, comprise garnetiferous biotite schists, quartz-feldspar-biotite paragneisses, thin quartzites and other transitional sedimentary varieties. With these are sometimes associated thin laminae and layers of calcareous quartzite, and some limestone strata, only the largest of which are mapped separately. Minor types, such as quartzite, quartz-mesh limestone, quartz schist and pyritous gneiss, are of restricted development, and of these the latter has the more general distribution. Certain amphibolites, in the lack of precise indications as to their origin, are questionably included in this series.

The amphibolites of the Pierrepont region, on the other hand, are believed to be, and those of the Little River-Pyrites belt are known to be, derived from an early gabbro intrusion, and the two masses are probably, though not certainly, continuous. South of Pierrepont Center the basic intrusive has formed an injection zone

Digitized by Google

with the garnet-gneiss as country rock; in the case of the Pyrites mass, numerous xenoliths of Grenville limestone and gneisses have been included, among them the narrow belt of pyritous gneiss at Pyrites which is the ore-bearing stratum.

The pink granite-gneiss occupies broad belts and smaller isolated subcircular areas; while generally foliated, it is rarely massive and saccharoidal. Pegmatite dikes of simple mineralogical composition are abundantly developed in the western area where they cut through Grenville silicious gneisses. Some of these penetrate the amphibolitic border of the gabbro formation, and the granite is believed therefore, though other evidence is lacking, to be younger than the latter. The granite contains abundant amphibolitic inclusions; in the absence of satisfactory data as to the derivation of these by the metamorphism of limestone, which nowhere shows contact alteration as distinct from regional, the xenoliths are viewed as inclusions of the earlier basic rocks caught up during the intrusion of the granite. Inclusions other than amphibolite are absent, and because of the apparent impotence of the granite to produce contact alteration, it is believed that widespread assimilation has not taken place in those portions of the magma now accessible to observation.

The schistosity has a general northeast-southwest strike and a northwest dip of 20 to 40 degrees; it ordinarily follows the banding or strike of the formations, but in numerous instances the latter intersects it at an angle as high as 90 degrees. Pitch, as applied to the directrices of folds of all sizes and to the elongation of mineral groups and individuals, is usually parallel to the direction of average dip, but may depart from it as much as 15 or 20 degrees. In the more western gneisses, on the contrary, it is almost parallel to the strike. On the whole, the axes of folds in the limestone, garnet, gneiss and other formations, as well as the elongation of xenoliths in granite, conform with remarkable constancy to this northwest pitch.

An important structure is the tilted sigmoidal isocline south and west of Pierrepont, which involves the broad belt of garnet-gneiss already referred to, and its peripheral amphibolitic and granitic injection zone. Its axes correspond to the regional pitch, its axial planes to the regional foliation and its limbs are parallel to the regional trend of the formations. Its greatest measured dimension is over 6 miles in an east-northeast direction; from top to bottom it measures 3½ miles, and it is perhaps the largest Precambric

Digitized by Google

structure of its type known. The wide departure of its axes from the formation trend is believed to point to at least two periods of orographic disturbance in this vicinity.

Igneous rocks are ordinarily in the form of sills. In the case of the gabbro these may represent stocks or bosses rolled out by dynamic readjustments, but many of the smaller masses were undoubtedly intruded as thin sheets to form an injection zone, such as that south of Pierrepont. In the case of the granite, the habit is much the same; but the sills are of huge dimensions and together with the smaller bosses probably represent the irregular surface of a regional bathylith.

In view of the limited area covered by the field work for this report, perhaps too much reliance should not be placed upon the broad generalizations here offered. Nevertheless they represent, in the writer's opinion, the weight of evidence for this quadrangle; but they are recognized as being subject to modification when viewed in the light of future more extended researches.

Professor Chadwick, who has been engaged with the Paleozoic rocks of this quadrangle, reports as follows:

The Paleozoic formations occupy the northern third of the quadrangle and occur also as several small outliers through the southern half. The northern outcrops are in general quite limited in number and in area, since the region is under a heavy cover of drumlin drift; they are confined chiefly to the beds of the Grasse river, Trout and Stony brooks, and the Raquette. While all the layers decline, broadly speaking, to the northward, following the present slope of the subsurface of Precambric crystallines, they present many minor undulations of gentle dip, crisscrossing like the waves of a choppy sea.

Along the contact of the main mass with the crystalline rocks that lie to the south, there exists a blank zone exceeding 1½ miles in breadth, in which bedrock is wholly concealed. The first outcrops seen on the north of this zone are small, often easily overlooked, exposures of the *Theresa beds* — upper semicalcareous Cambric strata. These are followed, usually immediately, by extensive ledges of a white vitreous "quartzite," 20 feet or more in thickness, containing numerous "Scolithus" and having much the appearance of the "white Potsdam" sandstone, with which it has evidently been confused in earlier explorations. Fine exposures of this are seen at Morley and northeastward to the Trout brook, thence southeastward along Stony brook to Sissonville on the

Digitized by Google

Raquette river. The discovery of large flat-coiled gastropods up to 3½ inches in diameter in this sandstone early threw doubt upon its supposed Potsdam age and led to the study of the better sections on the neighboring Ogdensburg and Brier Hill quadrangles. At Heuvelton, on the Oswegatchie, the field relations of the much more conspicuous ledges there widely exposed indicated a position above the Theresa division, which formation shows well in the falls below the dam; and this was confirmed by the succession of these strata in the nearly continuous section exposed along the St Lawrence river between Morristown and Ogdensburg. The heavy "twenty-foot" sandstone, carrying the large gastropods and "Scolithus," was found to lie far up in the "transition" series of mixed calcareous and arenaceous beds and to belong apparently in the base of the Canadian group (Ordovicic), corresponding to a part of what have been termed the "Tribes Hill" beds farther west and south.

The overlying, alternating sandy and dolomitic beds of the Tribes Hill formation are best displayed at Buck's bridge on the Grasse river and there carry well-preserved Pleurotomaria hunterensis[1] in the sandy layers; though farther west, as at Theresa and Heuvelton, these occur in the calcareous parts only. In passing eastward this formation has become far more arenaceous than in Jefferson county, so much so that it too has been included with the "Potsdam" in the earlier mapping. Its lithic characters are here much more like those of the (restricted) Theresa beds than is the case in the Theresa region, where the Tribes Hill outcrops at once suggest the higher marine Beekmantown.

What appear to be the top beds of this division are overlaid conformerly opposite the lower mills at Hewittville on the Raquette[2] by 10 or 11 feet of more calcareous strata of different aspect. These consist of drab calcilutytes, weathering light buff or greenish yellow, more or less shot with irregular, brown-weathering streaks of sand. In the Morristown-Ogdensburg section, 4 or 5 feet of similar beds are seen at the summit of the Tribes Hill; but at an intervening exposure on Trout brook they seem to be lacking though present again in a railway cut a few rods to the west. The appearance of an unconformity with the overlying purer dolomites of the Beekmantown at each of these three lo-

[1] Identified by Doctor Ruedemann.

[2] This locality is just over the line on the Potsdam quadrangle.

Digitized by Google

calities is thus emphasized by this discontinuity of the subformation. It is expected that these beds will be found to thicken eastwardly and to take on a more open-water character, whereas here they have many marks of a shoreward, shoal-water deposit. A small Maclurea-like gastropod is the only fossil observed in them.

The beds that succeed, apparently unconformably, are of normal "upper Beekmantown" character, mostly drab or gray dolomites, sometimes with a pinkish cast, though there are one or more sharply defined beds of white sandstone of "Potsdam" type in the series, and a limited amount of sand in scattered worn grains is likely to be found at any level, but its presence is not conspicuous. The rock generally has a velvety surface on fresh fracture. These beds are well seen along the Rutland Railroad at the Madrid-Potsdam turnpike crossing and near Norwood, and constitute the highest layers exposed on the Canton quadrangle.

Paleozoic outliers. Returning to the southern boundary, it is observed that the rock sequence above discussed lacks a base, and that no exposures of its lowest beds, where the substantial Potsdam sandstone is to be expected, are known on this quadrangle, and only the topmost part of the succeeding Theresa formation. A glance at the State geologic map will show that the Precambric crystalline rocks protrude far to the north on the meridian of Canton. A reasonable assumption, to which the field evidence offers no dissent, is that the Potsdam sandstone is entirely, or nearly, cut out across this quadrangle by an elevated area or monadnock in the Precambric erosion surface ("sub-Potsdam peneplain") north of Canton. There is abundant evidence about Canton of the ruggedness of this sub-Potsdam surface, and this would be merely repeating over a larger district what happens in a smaller way here and there about Theresa and on Wellesley island.[1] What comes the nearest to being an outcrop of the main body of white sandstone below the Theresa is an extensive exposure of cross-bedded saccharoidal sandstone with occasional large white quartz cobbles, in the bed of the Grasse river just above the county house. This small area is nearly surrounded by the crystallines, the actual contacts covered, however, and thus must fit a deep embayment in these, if it is not actually an isolated outlier. No great thickness is visible, though the ledges form two separate series of rapids.

[1] N. Y. State Mus. Bul. 145, p. 60.

Digitized by Google

Similar white saccharoidal sandstone, usually but little disturbed and with dips no greater than have been seen over the northern belts, occurs as outliers in separate localities along the east side of the Grasse river 2 and 3 miles respectively south of Canton. At the nearer of these the actual contact with the adjacent Grenville quartzite is excellently revealed, the latter beds standing vertically. Not far away are exposures of a more indurated and disturbed red or reddish sandstone of typical Potsdam character and revealing extensive brecciation and microfaulting. Often this rock is virtually a quartzite, though quite distinct in character from the thoroughly metamorphic Grenville. Small thrusts and monoclines are common. Some of the rock is highly autoclastic. These two types of rocks, with their color contrast even more pronounced perhaps, occur in very close proximity at the more southerly locality, where the *red* one is seen (as at several other points) in an equally unconformable but strikingly different type of contact with the Grenville quartzite and marble. The relations here are such that pertinence of the white and the red sandstones to the same formation seems open to question, though positive evidence of difference of age is not yet discovered. And these doubts intrude themselves at all the other localities examined, including the exposures north and south of Potsdam village. A distinction between these beds has been suggested by Cushing[1] for the Theresa quadrangle, with an erosion interval postulated on the basis of red pebbles incorporated in the white beds. It appears to us that no considerable age difference is indicated by the accumulating data and that Winchell's suggestion[2] of lower or middle Cambric age for the true red *Potsdam sandstone* of the Hannawa quarries (type locality) is hardly acceptable, though still possible.

SURFICIAL GEOLOGY

During the year past Professor Fairchild has continued his observations upon the changes in the postglacial waters. In the summer of 1913 his work was partly in the Champlain valley and partly, for purposes of comparison, in the valley of the Connecticut river. The manuscript copy of the forthcoming Churubusco or Ellenburg quadrangle sheet gave opportunity for determination of altitudes in the area near the Canadian boundary east and southeast of Covey hill. With the help of this map, it was found that the series

[1] N. Y. State Mus. Bul. 145, p. 62.
[2] *Vide* N. Y. State Mus. Bul. 95, p. 360.

Digitized by Google

of heavy cobble beaches at and north of Cannon Corners reached 735 feet in altitude, which is very near to the figure 750 feet which has been used for the theoretic height at the north line of the State. It seemed apparent that the up and down movement of the Hudson-Champlain valley must have involved the adjacent Connecticut valley, and therefore an exploration was made of the latter from Long Island sound to Wells River. This invasion of New England is also necessary for the study of the pleistocene of Long Island, since in position and in glacial history the latter area is a part of the former.

It was found that the phenomena of submergence in sea-level waters, so obtrusive in the Hudson-Champlain valley, were clear and abundant in the Connecticut valley. The high-level "terraces" and sand plains, of which much has been written, attributing them to deposits of the glacially-flooded river, are really delta deposits made in standing waters at sea level. The plains and terraces are partly contributed, as in the Hudson valley, by glacial outwash and partly by land drainage, and later somewhat distributed and shaped by river work at lower levels.

The origin of the plains in Massachusetts as static water deposits were recognized by Professor Emerson, and so described in his United States Geological Survey publications, Monograph XXIX, and Holyoke folio, no. 50. His water plane was taken as a datum plane, and it was found practically to mark the upper limit of the standing water from Middletown north to the mouth of Passumpsic river, about 280 miles. Northward from this point the valley was above the sea level.

In the Connecticut valley the uplifted marine plane has a northward rise of 2.30 feet a mile, nearly identical with the gradient in the Hudson valley which is 2.23 feet. But for equal latitudes the Connecticut plane lies about 50 feet higher than the Hudson plane, which makes the isobases or lines of equal uplift lie about 20 degrees north of west by 20 degrees south of east.

Following are some of the altitudes in the Connecticut valley: Riverhead, L. I., 120 feet; New Haven, Conn., 180; Middletown, 220; Hartford, 280; Springfield, Mass., 300; Brattleboro, Vt., 420; Hanover, N. H., 565; Wells River, Vt., 620. These are theoretic altitudes of the datum plane, but are very close to the actual levels of the summit terraces.

It appears that the west end of Long Island was mostly above this sea while the east end was mostly submerged. The heavy

Digitized by Google

moraines stood above the sea. The broad sand plains, so characteristic of broad areas of Long Island, are attributed to the submergence in the ocean as the ice sheet melted.

The Winooski valley in Vermont, opening at Burlington and heading east of Montpelier, is a replica of the Connecticut valley. It was deeply flooded by the Champlain sea-level water and exhibits well-formed high deltas. The history of its terraces is the same as for the Connecticut.

It is planned to publish as a bulletin of the State Museum the proofs of the marine submergence of the Hudson-Champlain valley and description of the phenomena. In this connection it will be necessary to make comparison with the corresponding features in New England.

The study of the surficial geology of the Saratoga quadrangle was completed by Professor Stoller and the final report, with map, submitted. Beginning was also made by him in the study of the glacial geology of the Cohoes quadrangle.

INDUSTRIAL GEOLOGY

The collections relating to the economic mineral materials of the State have been so largely augmented during the past season as to constitute practically an entirely new addition to the Museum. The materials have been assembled by solicitation among the representative industries and in part by personal canvass in the field. Although fairly complete exhibits of the kind have been prepared at different times by the Museum for the expositions at Chicago, St Louis, Portland and Buffalo, there has never been any attempt hitherto to incorporate a series of the products of our mineral industry as a permanent feature of the Museum itself. As a consequence, the collections previously made were largely scattered after they had served their purpose of temporary display, and much of the remnant returned to Albany has suffered damage from repeated removals from one storage place to another. A list of the new collections is included with the Museum accessions for the year.

It is proper to state that the plan of assembling such an exhibit has met with hearty cooperation on the part of the mining and quarry enterprises concerned, and that many have gone to considerable inconvenience and expense in preparing the necessary materials. Acknowledgment may be made in this place for the general support that has thus been received, without which the labor would

Digitized by Google

have been greatly increased and the results no doubt much diminished in value.

Mining and quarry review. The usual statistical canvass of the mineral industries was carried out, as a basis for the publication of a summary of the year's activities. The total production returned by the industries for 1912 had a value of $36,552,789. This indicated a period of general business expansion, since it was larger by nearly 17 per cent than the amount reported for the preceding year. In fact, the value of the output failed by only a small amount of reaching a new record, although the market conditions were by no means so favorable as they had been in some of the previous years.

In some branches of the mineral industry, New York State occupies a very prominent place and it participates in a large number of others which altogether contribute very considerably to the aggregate. There were thirty-five materials listed in the general table of products. The clay-making and quarry industries accounted for the largest items, the former with a total of $11,947,497 and the latter with an aggregate value of $5,718,984. These branches show great stability, but no marked tendency toward expansion from year to year. On the other hand, the cement industry, which in a sense competed with both the stone and clay-working industries, has made rapid strides of late years, after a period of vicissitude that nearly exterminated the once prosperous natural cement business of the State. With the decline of the latter, the portland cement branch was built up and has more than counterbalanced the loss of the former, with a gain in output over last year of nearly one-third. Similarly, the gypsum industry within a short time has developed from small proportions to a very important business that appears capable of further growth. The local mines supply a large share of the gypsum required by the Pennsylvania and New York portland cement plants which insure a steady market for the surplus rock. Most of the output, however, is used by the producers themselves for the manufacture of wall plasters and stucco. Another industry in which local enterprise is prominently concerned is the production of salt, both by underground mining and by evaporation of brines pumped from wells. Two of the largest salt mines in the country are located in Genesee county and there are more than twenty-five evaporating works distributed among six counties. The annual output is now above 10,000,000 barrels and is gaining steadily. The iron deposits of the State have attracted much attention recently and there is prospect of a

Digitized by Google

material enlargement of the productive industry which has long been an important one. Recently the resources of the Highlands region have shown the greatest interest perhaps, although developments have continued in the Adirondacks where the principal mines are now situated. Additional details in regard to the economic situation of the mineral resources will be found in the report already mentioned.

Report on quarry materials. Owing to the press of other work, it has not been possible to extend the investigation of the quarry materials beyond the crystalline rocks, and consequently the preparation of a comprehensive report on the subject which was mentioned last year as in progress has had to be postponed for the present. The matter already in hand has been made ready for publication and will be submitted for that purpose unless the field work can be resumed during the coming season. The part completed covers the crystalline silicate rocks and the marbles, the materials that have received the least attention in previous work in the field.

Molding sand. Some of the molding sand localities in the vicinity of Albany were visited last summer for the purpose of procuring samples for the Museum collections, and the opportunity was used to study the features surrounding the occurrence of this material. The origin of the sands and of their peculiar qualities which give them industrial value have received little attention hitherto beyond brief statements included in some of the areal reports on the Hudson river region and one or two other publications.

Stoller in his report on the "Glacial Geology of the Schenectady Quadrangle" remarks that the deposits in that vicinity do not occur at any definite level, but rise and fall with the surface contours, a feature which is true for the sands throughout the region. Although they are restricted to the flat-terraced area of sands, gravels and clays accumulated in the glacial Lake Albany, there is a variation of 200 feet in the elevations at which they are found in the section around Albany and Schenectady. Moreover, the sand in any particular locality follows the minor surface irregularities with a variation sometimes of as much as 20 feet between the high and low places. Any sudden and pronounced change in the topography, however, such as caused by a stream cutting into the terrace, marks the disappearance of the valuable sand. The thickness of the sand ranges from a mere film to several feet. Eight or 9 feet was stated by the gatherers as the maximum known to have been excavated in the vicinity, but the average is probably not over 30 inches.

Digitized by Google

The molding sand occurs directly under the soil and is succeeded by a layer of loose or "open" sand of variable thickness. The latter is usually of coarser nature and does not pack like the molding sand. It has a grayish color from admixture of shale with the quartz grains. Below this layer is found the Hudson river clay, yellow on top, changing to blue in depth.

The features surrounding the field occurrence of the sand appear to be exceptional for a simple water-laid deposit like the sand, gravels and clays that underlie it. It is not a definite bed or layer interstratified with the others and exposed at certain horizons, nor does it appear to have any counterpart in the series. It contrasts with the underlying sands in its fine, even grain, in its evidences of a weathered condition and in the fact that except for the intermixed clayey material is a very fine quartz sand. In its distribution it has the character of a surficial mantle that varies in thickness rather rapidly and also changes in vertical altitude more than would be expected from an undisturbed water-laid stratum.

The characteristic fine-grained sands which form the principal material shipped to foundries are made up of angular to subrounded quartz grains. Under the microscope the individual grains are frequently observed to possess sharply concave sides which are natural fracture surfaces of the quartz, developed no doubt by granulation under pressure. This points to a glacial source which, of course, is generally accepted as the origin for the whole series of detrital deposits, but there appears to be some indication of additional abrasion by other agencies. The angles are more or less rounded and the grains may show frosted or pitted surfaces, features suggestive of wind action subsequent to that of the ice.

Sufficient details of the field occurrence of the sand have not been assembled as yet to justify any conclusions as to the process by which the sand has attained its present distribution and attitude toward the other deposits. In some places, however, there is strong resemblance to eolian deposits, with modifications arising from their fixation by plant growth and subsequent weathering. Live sand dunes exist in the vicinity of the molding sands. Their materials are similar to the latter with the difference that they are not so well sorted and lack the weathered appearance which is always found in the true molding sands. It seems quite probable that the finer particles of these shifting sands are being sorted out by the winds and distributed over the surrounding area and may thus contribute some share to the upbuilding of the molding sand layer. There is little question that weathering influences by the breaking

Digitized by Google

down of the shale particles and the hydration and oxidation of their constituents, specially the iron compounds, exercise a beneficial change upon the material. The subject needs further study, however, in order to ascertain the specific effects wrought by the different agencies.

Miscellaneous. Field investigations other than those incident to brief trips for collecting purposes have been suspended during the year.

The office work has involved the usual extensive correspondence, of which a large part is concerned with the statistical canvass of the mineral industries. There has been a very active interest shown in the various undeveloped resources of the State, and numerous inquiries were received for advice as to possible locations for enterprise. These have related to almost all departments, but there seems to be particular interest at present in natural gas, iron ores, and high-grade limestones. It is aimed to give all possible assistance to legitimate requests of this character. The office has also been frequently called upon to identify and value samples of minerals, a function that is well within its province so long as there is not involved any elaborate chemical analysis or assay, in which case commercial laboratories must be consulted.

MINERALOGY

The time of the mineralogist has been given exclusively to the arrangement of the mineralogical collections, which is now well advanced. Reference has already been made to the acquisition of the Silas A. Young collection of minerals of Orange county which has been incorporated in the general arrangement. The mineral collections as now displayed constitute a double series, one being the general collection which has been made as complete as circumstances permit, and the other a series of New York State minerals which is undoubtedly the best of its kind.

PALEONTOLOGY

The attention of the paleontological staff has also been almost exclusively given to the arrangement of the paleontological collections. This work has been carried well forward, but the preliminary arrangement must of necessity be succeeded by a more permanent and carefully selected one. Into this collection of materials from the old Museum has had to be incorporated a large amount of material obtained by the purchase of the Gebhard collection. In addition to this work of arrangement of fossils, much has been done

Digitized by Google

toward the effective restoration of fossils, and to these reference has been made. A series of life-size restorations of the Eurypterida of the genera Pterygotus, Eurypterus, Eusarcus and Stylonurus, have been prepared, effectively colored, framed and set up in the Museum. The reproduction of Pterygotus, a New York species, is upwards of 9 feet in length, a statement which may convey some conception of the enormous size attained by these great arthropods of the shallow waters of the Silurian sea. Doctor Ruedemann has also very successfully rendered a series of reconstructions of the cephalopods, showing the interior structure as well as the complete form of the exterior. This series includes the genera Manticoceras, Gyroceras, Endoceras, Orthoceras, Piloceras, Trochoceras and Gonioceras, all on sufficiently large scale to bring out the structural details, which are not always clearly preserved in the fossils themselves.

In the face of the pressure of Museum work it has not been possible during the past year to accomplish any field work in paleontology or to carry forward in the office any extensive researches in this subject.

For a number of years past the paleontologist has made reference in these reports to the development of the New York fossil faunas and their containing formations in lower Canada, specially in the region of the Gaspé peninsula. During the summer of 1913 the twelfth meeting of the International Geological Congress convened in Toronto, and among the geological excursions that were prepared in connection with that meeting was one into the Maritime Provinces including the Gaspé peninsula. At the request of the Canadian authorities, the paleontologist prepared a guide for the part of this excursion embracing the Gaspé peninsula and a portion of northern New Brunswick, and was privileged to act as guide over part of the course. This inviting excursion was participated in by about seventy geologists from various parts of the world, among them being the directors of the Geological Surveys of Great Britain and of France, as well as distinguished workers in this field from all the countries of Europe, from Indo-China, China, Japan, South Africa and the isles of the sea. Inasmuch as this field has been so fully exploited in the reports of the New York Geological Survey, it seems altogether appropriate now to present here a summary opinion of its geology by the director of the Geological Survey of France, M. Pierre Termier, recently published in the Proceedings of the *Academie des Sciences*. For these very ex-

Digitized by Google

Panel restoration of the Siluric merostome P t e r y g o t u s b u f f a l o e n s i s. Actual length of animal, 9 feet

Digitized by Google

Digitized by Google

Life-size panel restoration of the Siluric merostome Eusarcus

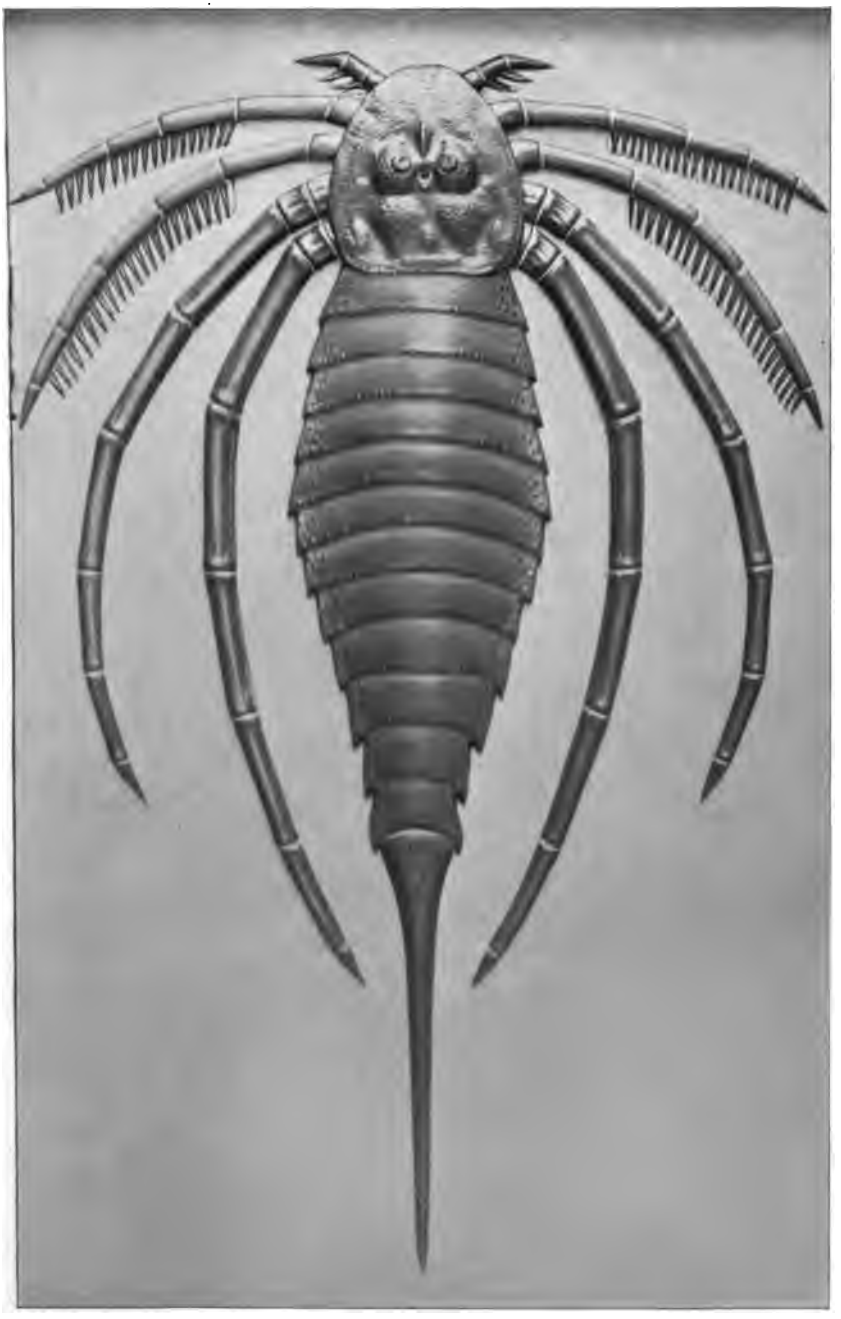
Digitized by Google

Digitized by Google

Life-size Eusarcus habitat group. Submarine view showing the ancient merostomes in their natural surroundings during the period of the Bertie waterlime (Siluric)

Digitized by Google

Digitized by Google



Life-size panel restoration of Stylonurus excelsior from the Catskill mountains

Digitized by Google

Digitized by Google

Model of a giant Endoceras from the Ordovicic rocks

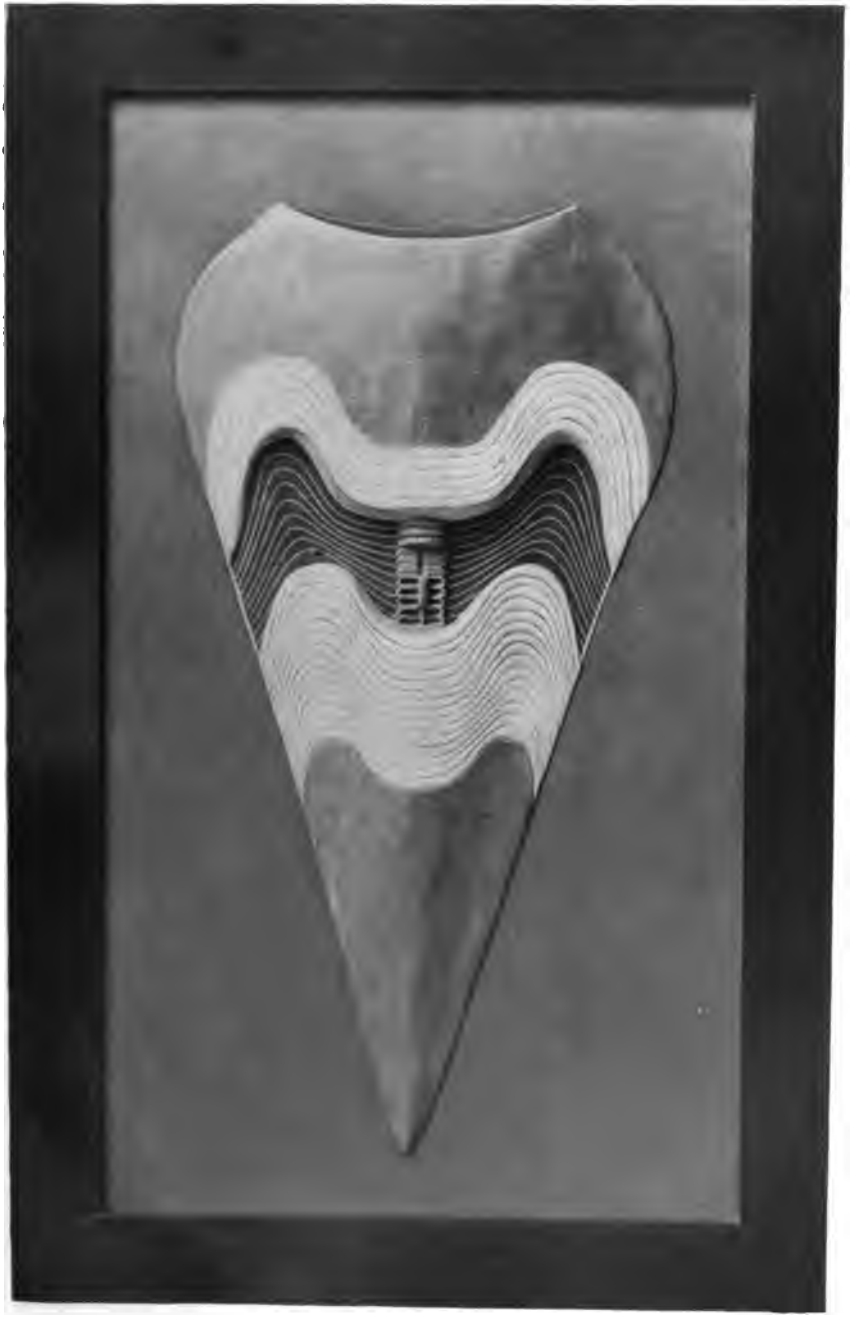
Digitized by Google

Digitized by Google

Restoration of the internal structure of the cephalopod Piloceras

Digitized by Google

Digitized by Google



Restoration of the Ordovicic cephalopod, Gonioceras

Digitized by Google

Digitized by Google

Slab of Devonic starfish from Saugerties, N. Y., as mounted in the Museum. This slab measures 4 feet 9 inches x 4 feet 9 inches and carries 190 starfish. View taken from above

Digitized by Google

Digitized by Google

cellent reasons, a translation of M. Termier's summation of his observations in the field is herewith attached:

This excursion led us across the region of the primitive rocks, some of them much folded, some only undulated or even nearly horizontal, and which lie between the St Lawrence river and the Atlantic coast of Nova Scotia. I call this country the Appalachian region of Canada; for it is the prolongation, in Canadian territory, of the primary folded region known as the Appalachians which plays so important a rôle in the eastern United States. The same folded belt extends farther on to the north, to form Newfoundland; it then buries itself beneath the waters of the Atlantic, and Marcel Bertrand believed that he had seen it, in the ocean depths, joining the folded Armorican belt.

The interest of this excursion, to my mind, was twofold: stratigraphic and tectonic. Under guidance of the best authorities, the whole primary series, almost complete, and often rich in fossils, to discern the folds of this series; to follow them and fix their date, in a folded belt not less than 600 kilometers in width and the length of which we failed to cover in more than 500 kilometers; it is that which occupied and enamored us for eighteen days.

The Appalachian region of Canada parallels the southeastern border of Laurentia, pressing and molding itself against it. It is well known that Laurentia (of Edouard Suess), still called the Canadian Shield, is an immense domain of the earth's surface lying as though frozen down since Cambric times. All the beds belonging to it which are not earlier than the Cambric, are horizontal. They may be faulted and eroded; they are not rearranged nor folded. This anchored Laurentia comprises the greater part of Canada. At the south it reaches well into the United States; at the west to the Rocky mountains; on the northwest to the Mackenzie river; at the north as far as the mountains recently discovered in Ellesmere, Grinnell and Grant Lands; on the northeast it extends beneath the Atlantic, and the ancient north Atlantic continent, of which Greenland and Iceland are only the debris, seems to belong to it. Quebec is a point on the southeast margin of Laurentia. To the northeast of Quebec this margin coincides with the valley of the St Lawrence; it trends down-river toward the east, then toward the southeast along the coast of Gaspesia passing between this shore and the south coast of the island of Anticosti, and regaining its direction toward the northeast, passes along the Straits of Belle Isle, to lose itself at once in the Atlantic. To the southwest of Quebec the southeast border of Laurentia crosses the valley of the St Lawrence, then, little by little, taking a south-southeast direction and even an almost due south course, coincides with the long depression of Lake Champlain. Wherever it can be seen, the southeast border of Laurentia is a great fault. The two regions separated by the fault are in striking contrast: contrast in the aspect of the paleozoic lands, here perfectly horizontal, there folded, twisted, some times crushed; contrast in the relief of the ground, much more strik-

Digitized by Google

ing than in Laurentia which is a country overelevated and formed of hard rocks while the folded paleozoic country is a low land, profoundly worn, and with gentle curves.

There are few regions on the surface of the earth where the present geography is so intimately bound to a very ancient geography, where the present relief has so great an antiquity as in the Appalachian region of Canada. One may say that since the Cambric or at least since the lower Ordovicic, the St Lawrence has flowed as it does today from the place where Quebec now stands; sometimes in the condition of a marine channel, long and straight, turning to the south of Anticosti and passing through Belle Isle; sometimes as a vast fluvial valley collecting the waters of the immense American continent and carrying them to the sea by way of the Cabot strait, as it does today.

All about the Gulf of St Lawrence the plan of the coasts is an ancient plan, determined in its ground lines by phenomena earlier than the Carbonic. The peninsula of Nova Scotia, with its curious shape, is a Precarbonic link formerly connected with Newfoundland, partly covered by the whole of a transgressive series which has remained horizontal but manifests nevertheless the Precarbonic aspect in the alinement of its hillocks and its coasts, in the rias which characterizes the entire island of Cape Breton. The Bay of Fundy has not changed since Triassic times and in those times it resembled very much what it had been during the Carbonic. It requires but little imagination to see this country as it was in the different epochs of the Paleozoic, in the Gothlandic, in the Devonic, in the Westphalic, in the Permic. In very truth, if any member of the human family had lived in those times so prodigiously remote, for example at the end of the Devonic, if he had then traversed all this region already folded and prepared for the great Carbonic transgression, and if he could return today after millions of centuries of sleep and exile, to Gaspesia, New Brunswick or Nova Scotia, it would not seem at all a strange land to him.

The great orogenic movements in the Appalachian region of Canada are of Devonic age. As always, they had been slowly prepared by preliminary movements, and for a long time after them the ground continued to undulate. Preliminary movements and posthumous undulations have had, broadly speaking, the same direction as the principal folding. The most ancient preliminary movements date back to the Cambric. It is in the Cambric that history ceased to be the same for Laurentia and for the Appalachian region.

The age of the principal folding is perhaps not everywhere exactly the same. In Gaspesia and about the Bay Chaleur where there are two highly fossiliferous Devonic series, one lower Devonic, the other upper Devonic, and where the great discordance lies between the two, the principal plication is dated with reasonable precision — the middle Devonic. No part of it seems to have been delayed into the Dinantic.

Digitized by Google

The principal folding, of Devonic age, was extremely energetic. The folds are often greatly squeezed with a general tendency to leaning to overthrust toward the northwest. It is the push toward Laurentia, as intimated long ago. This may have resulted in the formation of veritable sheets which have gradually disappeared. We have seen one indisputable overthrust, that of the Ordovicic of Cap-des-Rosiers by the Lower Devonic of Cap-Bon-Ami and Grande Grève, at the extreme point of Gaspesia. The surface of displacement, unfortunately not very clear, dips here to the southeast at an angle of about 30°.

Very often the folds are straight and the beds vertical. Phenomena of crushing and foliation have not seemed to me very frequent or very intense. I have seen them, however, very beautifully developed in the Bathurst iron mine south of the Bay Chaleur —a foliated microgranite, having the aspect of gneiss and even the appearance of glazed slates, gray or clear green, in a band of folded Ordovicic. There are analogous compressions, and much more abundant, in the azoic rocks of Nova Scotia, granites and diabases on the east coast of the Bras d'Or, auriferous slates and granites in the region of Halifax; but these terranes are probably Precambric and their folding belongs to an epoch much more remote than the Appalachian folding.

The folds of Devonic age are, in a general sense, directed southwest-northeast. They are the ones which, as I have above said, determine the prolongation of Nova Scotia and the island of Cape Breton; likewise those which determine the rias of this island and those of Newfoundland. But the easternmost of these folds, those that are close against the margin of Laurentia, bend downward, beginning at St Anne-des-Monts, parallel to the coast of Gaspesia. At Gaspé and Percé, they are oriented toward the southeast. It is clear that this sinuosity is quite local and that the same folds, concealed today at the bottom of the Gulf of St Lawrence, regain soon between Anticosti and the Magdalen Islands, the northeast direction. The Carbonic mantle of New Brunswick conceals from view the same sinuous effects in the Devonic plications of this province. It seems as though we had an analogous sinuosity, but highly attenuated, on the east coast of the Bay of Fundy, on the long fjord (Minas bay) and in the country which extends from Truro to Arisaig. It will then be manifested by posthumous undulations much more than by the almost invisible Devonic folds. At any rate the sunken region of the ancient Devonic chain, which has become the Gulf of St Lawrence, corresponds to an energetic destruction of plication and it seems to me that under the waters of the gulf all the folds of Gaspesia are squeezed and crushed along the west coast of Newfoundland. This great Devonic chain, at least 600 kilometers across, where widest, and even 400 kilometers on the north of Newfoundland, doubtless continues well beyond that to the northeast. But does it go, as Marcel Bertrand thought, toward the south of England and toward Bretagne? I do not think so, now that I have seen it. The Devonic chain of Canada

Digitized by Google

is an *arrested Caledonian* chain; I mean to say by that, a branch of the great chain of northern Scotland, of a little later date than the Scottish stock. It is with the Highlands of Scotland that the old Newfoundland mountains seem to me to be in agreement.

Here, as there, upon the partly leveled Caledonian folds extend, transgressive and rich in coarse conglomerate, the red sandstones. Those of Canada are a little more yellow than those of Scotland and their highest members are of Dinantic age. These red sandstones of Canada, dated, here and there, by fishes or by plants, are often nearly horizontal. The Bonaventure, the Scaumenac, the Horton Bluffs formations belong to them. The so-called Windsor beds (with brachiopod limestones and frequent gypsum masses) seem to me to be the upper element of this complex and incontestably Dinantic.

After the deposition of this mantle of red sandstones, and doubtless toward the close of the Dinantic, began a new movement, of slight intensity, gently displacing the coasts and producing here and there lacunes and discordances in sedimentation. For over a restricted area of the ancient chain, an area covering the northeast portion of New Brunswick, Prince Edward Island, Cape Breton and northwestern Nova Scotia, the Westphalic is deposited almost everywhere to an enormous thickness. The base of the Westphalic is often designated by the name Riversdale and Union formation and correlated in a broad way with the Millstone grit. It incloses many beds of red sandstones or schists, and numerous black schists with Leaia and Anthracomya. This group alone may have a thickness of 3000 meters. The upper part is a productive coal, very actively exploited at different points (Stellarton, Pictou, Sydney etc.) with a thickness of 600 meters at Sydney, more than 2000 meters at the Joggins. It may be that the most elevated of these coal beds are Stephanic. There was a new movement again, a new discordance or a new formation of conglomerates in the Stephanic epoch. The New Glasgow conglomerate is at the base of a very heavy series of coarse conglomerates, the upper part of which is Permic and which form today all of Prince Edward Island and almost the whole isthmus which attaches Nova Scotia to the mainland. The Trias of the Bay of Fundy which extends as far as Truro, corresponds to an analogous episode, but much later and affecting a region which the Permic transgression did not reach.

Trias and Permic have remained nearly horizontal. In the vast Carbonic mantle, the thickness of which will reach about 4000 meters, there are, generally speaking, only undulations, but accompanied by truncations through faulting. The coal of Sydney and Glace Bay disappears gently beneath the sea with a feeble dip and a perfect regularity and the workings are boldly going forward beneath the waters of the Atlantic. Nowhere have we seen the Carboniferous actually folded. It is, nevertheless, at certain points in southern New Brunswick and at Pictou, but such local folds are not intense, it seems, except in the early Carbonic.

Digitized by Google

The stratigraphic analogies between the Carbonic of the Maritime Provinces and that of England and the north of France are everywhere remarkable. They were pointed out long ago. But, tectonically speaking, there has been no direct connection between the Appalachians and the European coal chain. In Canada the Appalachian chain is a chain of Middle Devonic age, thus a Caledonian chain; and the movements which have affected it, at different times, in the Carbonic, the Permic, perhaps also at the end of the Trias, are very slight movements, which are entitled to be designated only as posthumous movements. Farther southwest, in the United States, these posthumous movements became gradually more intense and have built up a real chain, a true range of *American Altaids* in the exact prolongation of the *Canadian Caledonids*.

Digitized by Google

III

REPORT OF THE STATE BOTANIST

(During the past year the work of the office has practically passed into the hands of Dr H. D. House, assistant in botany, who took the place of S. H. Burnham, resigned, and who has prepared this report.)

Noteworthy contributions. Specimens of ten species of Crataegus have been added to the herbarium. These were collected by Dr J. V. Haberer, in central New York, and are the co-types of species described by Prof. C. S. Sargent in the report for 1912. Nearly all the 218 known species of Crataegus in this State are now represented by specimens in the herbarium. Doctor Haberer has also contributed four new species of Antennaria, to be described later by Dr E. L. Greene of Washington, D. C., a specialist upon that group. Doctor Haberer's set of plants also includes several other species either new to the State or new to central New York. Mr A. Olsson of Gloversville has collected and presented to the herbarium a large number of Fulton county plants containing several additions to the flora of the State and to Fulton county, the most interesting being a small orchid, Ophrys australis (Lindl.) House.

Dry weather damage to maples. About the middle of July several inquiries were received concerning damage to maple foliage. The first noticeable effect was a bronzing of the leaves, followed by the withering and death of the leaves when they turned brown but remained attached to the limbs, thus causing a very unsightly appearance. Most of the complaints apparently considered the damage due to either fungus or insect enemies of the tree. By the last of July the damage seems to have been generally noticed on shade and park maples throughout most of the State. A personal examination of some of the badly affected trees in towns of the central part of the State and about Albany resulted in an explanation of the damage.

July was ushered in by about ten days of unusually hot weather, following a considerable period of drought, with high temperatures prevailing on some days. While the week of July 6th was a little cooler, the drought continued, and in fact the precipitation for the entire summer was far below normal. On July 12th and 13th there occurred a strong hot and dry westerly and southwesterly wind, which continued with greater or less strength for several days.

Digitized by Google

A group of fungi cast in wax

Digitized by Google

Digitized by Google

The maple is well known as a very shallow rooted tree and the effect of the dry wind upon transpiration in the leaves is very marked in the case of any tree. It is apparent that the period of drought preceding the early part of July had reduced the available water of the soil to a minimum, so that the factors favoring transpiration (that is, dry, hot winds) which followed, greatly exceeded the power of the trees to absorb water from the soil which was actually deficient in moisture. Such a condition of affairs was particularly active in the case of maples along streets, highways, in parks or other situations where the soil was not protected by litter or undergrowth from drying out.

The leaves of the maple being unable to maintain the high rate of transpiration necessary under such conditions, were susceptible to the chemical activity of the sun's rays, causing the bronzing effect, a chemical change of the cell contents, somewhat analogous to what takes place normally in autumn when the leaves turn to shades of red or yellow. In many cases this state was followed by withering and death of the leaves, as sufficient moisture was not available to revive the leaves and to maintain their turgidity, which alone keeps them under ordinary conditions from collapsing.

That the dry weather and dry winds mentioned were responsible for the widespread damage seems probable also from the fact that the trees in situations of permanently damp soil, as in deep woodlands, suffered little or not at all; and of the trees affected, the greatest damage seems to have been on the side exposed most directly to the wind. Elms, having deeper-going roots, did not suffer so much as the maples, although considerable damage to their foliage was noticed in the case of some trees growing in dry soils. The leaves of the elm also possess a thicker epidermis and are better adapted by structure to withstand the factors like wind and heat which favor excessive transpiration and its subsequent damage.

The injury to maple and elm foliage thus noted is not likely to be permanent, nor is it likely that the trees thus affected will suffer from more than a slight setback. The damage consists chiefly in the unsightly appearance of the foliage. Local and even widespread occurrence of this sort of damage has frequently been reported in former years but not with such severity as during the past season.

A new fungus enemy of the maple. Several ornamental sugar maples at Glen Cove were observed by Mr F. E. Willets to be suffering from the attack of a fungus which caused the death of numerous twigs and branches, so that by August the trees were

Digitized by Google

quite unsightly with the accumulation of dead twigs and brown leaves upon them. The fungus has been identified as Steganosporium piriforme (Hoff.) Cd., and it is said to have been destructive to maples in a town in southern Minnesota at one time. It seems, however, not to have been previously noted in New York State. It is not usually regarded as a serious enemy of the maple and its destructive work at Glen Cove may be due to a combination of circumstances, not the least of which was the weakened condition of the trees due to the excessive and prolonged drought.

Weather and fungi. Numerous observations in former years have led to the conclusion that unusually dry seasons were productive of but few forms of fleshy fungi, and Doctor Peck makes special comment upon the abundance and variety of fungi following a damp or rainy summer (Report for 1912, page 9). The season of 1913 seems to furnish abundant support to his conclusions for in most parts of the State few fleshy fungi developed during the summer season of 1913, although numerous common ones appeared late in the fall and a large crop of field mushrooms followed favorable late summer rains in most localities. Many correspondents have concurred in attributing the scarcity of fleshy species during the summer to the unusually dry weather.

Condition of the collections. The collections having been moved to the new Museum quarters early in the year, much time was necessarily occupied in properly arranging the herbarium and duplicate specimens in the new metal cases.

The collections of fungi made by the staff or received through contributions during the past year have been placed in cardboard boxes suitable for their reception and arranged in their proper places in the herbarium. The collections (345 in number) include 55 specimens of fungi and 290 specimens of ferns and flowering plants, collected in the counties of Albany, Madison, Rensselaer, Oneida, Onondaga, Schenectady and St Lawrence.

Specimens were contributed from the counties of Fulton, Herkimer, Monroe, Oneida, Onondaga, Queens, New York, Richmond, Washington and Wyoming.

Correspondents have contributed extralimital specimens collected in Alabama, Canada, California, Colorado, Connecticut, District of Columbia, Illinois, Maryland, Minnesota, New Hampshire, New Jersey, North Carolina, Oregon, Pennsylvania, Utah, Washington, Wisconsin, Wyoming, and Porto Rico and Germany.

The number of species of which specimens have been added to the herbarium from current collections and contributions is 128,

Digitized by Google

of which 62 were not before represented in the State herbarium. Of these, 6 are considered new or hitherto undescribed species.

In addition, 2622 specimens have been placed in pasteboard boxes, labeled and properly incorporated into the herbarium from the stored material. The following synopsis shows the number of such specimens now added to the herbarium, but heretofore stored away in bundles and not easily accessible:

	NEW YORK	EXTRALIMITAL
Agaricaceae	1160	293
Polyporaceae	333	205
Boletaceae	260	140
Other families	118	113
Total	1871	751

The total number of specimens added to the herbarium, from all sources, is therefore 2740. This large addition is made possible by the enlarged space now available for the herbarium in its new quarters.

A list of the names of the added species (not including those added from the stored material) shows which species are new and which are not new to the herbarium.

The number of those who have contributed specimens of plants is 33. This list includes the names of those who sent specimens for identification only, if the specimens were of such character as to make them desirable additions to the herbarium.

The number of identifications made is 830; the number of those for whom they were made, 110.

Digitized by Google

IV

REPORT OF THE STATE ENTOMOLOGIST

The State Entomologist reports that two leaf feeders attracted general notice the past season, namely, the *apple tent caterpillar* and the allied *forest tent caterpillar*. The former, devouring the leaves of many orchard and wild cherry trees, was easily recognized by the large nests in the forks of the limbs. It was particularly injurious in the upper Hudson and Mohawk valleys. The latter pest, distinguished by the somewhat diamond-shaped, silvery white spots down the back, defoliated extensive areas of oaks on Long Island, attacked the sugar maples in the upper Hudson valley and stripped poplars in the Adirondacks. The probabilities of such injuries were foreseen last year and timely warnings issued. A number of rare or particularly interesting species have been observed during the year, and brief notes concerning a number of them are given in the Entomologist's report.

Petroleum compounds as insecticides. The serious condition of many sugar maples, following the application of miscible oils in 1911 and similar trouble in several apple orchards in 1912, was followed up the past season by studies of some cases and these, in connection with certain experiments, have resulted in confirming the Entomologist's opinion as to the cause of the trouble. This is a matter of much practical importance, since the injudicious use of these materials may jeopardize the existence of hundreds of valuable shade or fruit trees. The details of this work are given in the Entomologist's report.

Fruit tree pests. The studies and experiments of the last four years on the *codling moth* were continued. In midsummer some fruit growers became apprehensive of severe injury by larvae of the second brood. Examinations failed to disclose a substantial basis for such fears, and this opinion was confirmed in October by observations made in the orchards of Messrs W. H. Hart of Arlington and Edward Van Alstyne of Kinderhook. The owners sprayed under strictly commercial conditions and with no expectations that the trees would be subjected to a test later. There was a good crop and it was found that from 95 to 97 per cent of the entire yield were worm-free as a result of one timely spraying.

A small parasite has been exceedingly abundant and widely distributed in orchards infested by *San José scale,* and in not a few instances has been an important factor in reducing the numbers of the pest. Observations show that in most cases the trees in un-

Digitized by Google

sprayed orchards were seriously injured in earlier years and, as a rule, he believes that fruit growers must continue to rely upon applications of lime-sulphur washes for the control of this pernicious enemy.

Injuries by *red bugs*, two very similar species of which are known to occur in New York, were so abundant in one orchard near Poughkeepsie as to deform about one-third of a large crop of greenings. A brief account of this outbreak is given in the Entomologist's report.

The work of the *pear thrips*, one of the newer fruit pests, was studied in the vicinity of Athens, and a marked localization of injury observed as in earlier years. A detailed account of this insect has been given in the Entomologist's report for 1912.

The *pear psylla* is a pest of considerable importance, especially in the western part of the State, and occasionally very injurious in the Hudson valley. Incidentally the practical value of late spring applications of a lime-sulphur wash for the control of this insect was demonstrated in a badly infested orchard near Athens.

A new grape enemy which may become of considerable importance to growers in the Niagara section, in particular, has been discovered. It may be known as the *banded grape bug*. Its work is described and a discussion of its habits and the best methods of control are given in the Entomologist's report.

A number of other insect pests of fruits have been studied and records concerning them are given in a series of classified notes.

Gipsy moth. The small colony of the gipsy moth discovered last year appears to have been completely exterminated. This occurrence proves, in a concrete manner, the ever present possibility of the insect becoming established in New York territory, and amply justifies the maintenance of rigid precautions to prevent this. Evergreens and shrubbery grown in sections where gipsy moth is known to occur should be examined most carefully; especially is this true of the former. The presence of broken egg masses usually means the occurrence of living eggs in the packing material or about the roots of the plants in the same bale or box, and a due regard for the public welfare necessitates the destruction of the shipment or the part of the shipment exposed to infestation of this character.

Brown-tail moth. There is little to report concerning the brown-tail moth, though the danger of its establishing itself in the State has not decreased. It is only a question of time before this occurs. The winter nests are so characteristic that there should be little difficulty in recognizing the pest and at the outset preventing its becoming extremely abundant.

Digitized by Google

Grass and grain pests. The white grub outbreak of last year has largely abated, partly at least as a result of various natural causes. The studies of last year have been continued. The most interesting development was the discovery of many large, beneficial maggots, probably a species of Erax, which were abundant in fields badly infested by white grubs the preceding year, and at the time of observation last spring, nearly free from the pests.

A rare or usually overlooked corn pest, the *lined corn borer*, was destructive in Ulster county fields. A full discussion of this relatively new insect is given in the Entomologist's report.

The discovery of the *European wolf* or *grain moth* in a local seed warehouse adds another to the list of important grain insects. A careful study has been made of this insect and a detailed discussion appears elsewhere.

Shade tree insects. Observations show that the comparative immunity from severe injury by the *elm leaf beetle* the past season is probably due to the exceptionally cool weather in June, a time when the laying of eggs by this pest is at its height and the period when adverse climatic conditions might be expected to exert a maximum influence. There have been some cases of very severe injury locally here and there, due probably to a decreased vitality of the trees and a speedy destruction of the abnormally small leafage. It is undoubtedly true that the more thorough spraying by certain communities during the last few years has been most beneficial. The apparent check of the past season is presumably temporary and any extended reliance thereupon is considered inadvisable.

The *false maple scale* has been the cause of a number of complaints, though it has been distinctly less numerous than in recent years. It was extremely abundant during late summer in one locality at Mount Vernon.

The *tulip tree scale*, a pest occasionally numerous, was unusually injurious in the vicinity of New York City. Several natural enemies were noted preying upon this species.

Forest pests. Work has been continued upon the *hickory bark beetle*, and field observations by the Entomologist lead him to believe that the period of severe injury for the vicinity of New York City has largely passed. His investigations of previous years and the studies of this season indicate the practicability of protecting the more valued trees by applications made shortly after the beetles have entered the bark. The probable efficacy of this treatment by no means lessens the advisability of cutting and burning badly infested wood before the borers can mature and escape.

Digitized by Google

The extensive plantings of white pine in recent years have given the *white pine weevil* almost ideal opportunities for multiplication and, as a consequence, there have been numerous complaints regarding the work of this insect. The Entomologist, in cooperation with Mr Waldo C. Johnston of Cooperstown, conducted a practical test of the value of collecting the weevils by hand. It was found that four collections could be made for about $1.25 an acre where the trees were not more than 3 feet high and, as a result, no weevils were to be seen later. There are reasons for believing this to be a practical and possibly a profitable method of controlling the pest in such plantings. It is planned to continue the investigations of this important pest.

Original studies were also made of the *spotted hemlock borer,* an insect which destroyed several hundred valuable hemlocks in the New York Botanical Gardens, and one which has killed many trees in the Appalachian region. A detailed account of this borer is given in the Entomologist's report.

The *Rhododendron clearwing* and the *pitted Ambrosia beetle* were also studied. The first deforms and weakens the valuable Rhododendron, while the latter may destroy a considerable proportion of one or more beds of this shrub.

The work of the *two-lined chestnut borer,* a pernicious enemy of both chestnut and oak, was observed in several localities about New York City and appropriate recommendations made. A detailed account of this pest has been given in New York State Museum Memoir 8.

The Entomologist has taken advantage of the recent outbreak by *bark beetles,* to study the general conditions which may result in serious injury by these borers. A careful examination of weather records, especially those relating to precipitation, tends to support the belief that a series of annual droughts may so weaken the trees as to produce conditions very favorable for the multiplication of the borers. A discussion of the data is given in connection with an account of the hickory bark beetle.

Flies and mosquitos. The interest in the control of the *house fly* and the subjection of the *mosquito* has continued. Several warning notices were sent out early in the year and a brief folder on the house fly was prepared, the latter being widely circulated in early summer.

Gall midges. Studies of gall midges have been continued and a number of species and three new genera described. The practical character of this work is illustrated by the description of one midge

Digitized by Google

which is considered a most important natural enemy in controlling the red spider on cotton, and a consultation has been held with Prof. Henry Tryon of the "Prickly Pear (Traveling) Commission" respecting the introduction of certain gall midges into Queensland, in the expectation that they might become important agents in practically freeing large areas from the introduced and obnoxious prickly pear. The Entomologist's report contains a detailed account of a *Cactus midge* which may prove of great value in Australia, though regarded as a pest under certain conditions in this country. The *rose midge*, an important enemy of the rose grower, has caused considerable apprehension in the vicinity of Rochester on account of its injuries to young plants.

Publications. A number of brief popular accounts regarding such common pests as the house fly, apple tent caterpillar and forest tent caterpillar have been widely circulated through the press. The most important publications, aside from the report of last year, are: The Gall Midge Fauna of Western North America; Studies in Itonididae; and several papers describing new species of gall midges.

Removal. The moving of the collections and their establishment in the new quarters in the Education Building involved a large amount of work, which necessarily restricted activities along other lines and must continue so to do until the insects are permanently rearranged. The removal was accomplished with practically no breakage or loss of either specimens or equipment and with comparatively little hindrance to the regular office routine.

Faunal studies. This phase of entomology has received some attention almost from the establishment of the office and has an important bearing upon practical work, since data of this character make possible the fixing of boundaries beyond which there is little probability of injurious species maintaining themselves in numbers. Earlier unpublished studies have resulted in fixing approximate boundaries for the various life zones in the State. It has been the policy for some years to collect in representative areas whenever opportunity offered and much valuable material has been secured in this manner. Collections in the Adirondacks, begun by the late Dr J. A. Lintner, have been continued. The past summer collections were made in several Adirondack localities and at Wells. These data are now being prepared for publication.

Collections. A special effort has been made the past season to secure specimens of the work and early stages of various injurious forms, since biological material is a most important component of economic collections and indispensable in elucidating the habits and

Digitized by Google

life histories of the various species. The State collection now contains a large amount of such material, invaluable because of the associated data. Many miscroscopic preparations of smaller insects have been made and incorporated in the collections as in earlier years.

Much labor has been expended upon the rearrangement of the collections, an undertaking which has been hampered to some extent by insufficient case or tray room. This work, while time consuming and in a certain measure unproductive, is a necessary preliminary to effective studies in the future; otherwise more time would be lost in endeavoring to find misplaced specimens than would be required to put the collection in order in the first place.

Material provision for the care of the collections is essential. The pinned insects are in boxes or trays in wooden cases. There are not enough of the former to permit the specimens being properly arranged, and the latter should be replaced by steel cases and more provided to accommodate the additional boxes and trays required. The biological material is in an even less satisfactory state. It is in shallow, wooden trays and difficult of access because of the lack of space. There is need of a modern series of metallic trays for the accommodation of such specimens. Some equally satisfactory provision should be made for the large collection of microscopic slides, many of them containing types of species, and therefore impossible of duplication. The constantly increasing collection of photographic negatives requires a metallic filing case of approved design.

Nursery inspection. The nursery inspection work conducted by the State Department of Agriculture has resulted in the Entomologist being requested to make numerous identifications and also advise in regard to the policy which should be pursued by the State. Many of the specimens submitted for name were in poor condition, and as they may represent any stage in insect development and frequently originate in a foreign country, such determinations are laborious, time consuming and require for their successful prosecution a large collection and many entomological works, both domestic and foreign. The correct identification of such material is very important, since the disposal of large shipments of nursery stock depends in considerable measure upon the character of the infestation.

Miscellaneous. Cooperation with the Division of Visual Instruction has been continued and additions made to an excellent and somewhat extended series of photographs, mostly of injurious or common insects or their work.

Digitized by Google

V

ZOOLOGY

In spite of the temporary lack, or inaccessibility, of many things essential to the work of the zoology section, substantial progress has been made in restoring an orderly arrangement of the collections and in acquiring the equipment necessary for meeting the requirements of a zoology exhibit much larger and more varied than could be attempted in the former quarters. In the early part of the fiscal year, the removal of the collections and outfit of the zoology section was successfully accomplished. The time and labor previously devoted to packing and preparing the collections proved well spent; the packed material was all handled rapidly and easily and arrived in good condition. On account of the delay in delivering the zoology storage cases, boxes and wrappings have been obliged to do long service as storage. While by no means adapted for protection against insects, depredations from that source seem to have been effectually warded off by opening up the boxes and examining the specimens as soon as warm weather came on, and putting in each box a plentiful supply of naphthalene. No damage from insects has been found in the material thus far taken out.

The special groups of birds and animals having more or less elaborate accessories, such as prepared or artificial plants, celluloid or glass representing water, etc., presented great difficulties in moving on account of their bulk and liability to injury. They were carefully transported without packing, but not without considerable damage, due largely to the partial dismantling made necessary by the narrow and crooked stairway and lack of an elevator in Geological Hall.

The group of fresh-water fishes prepared by Mr Klein while taxidermist at this Museum was found most difficult to handle. The large sheet of celluloid representing the surface of the water cracked, causing considerable damage, apparently because of the sudden change in temperature due to moving it in cold weather, every care having been taken in handling it.

The large group of black bears acquired several years ago and temporarily set up at the State Normal College for lack of room in Geological Hall, was also moved to the Education Building, but on account of its large size, it had to be entirely dismantled and nearly all the accessories replaced. The moose group, which

Digitized by Google

had been in storage since its delivery in Albany, was also moved but not set up, owing to the delay in delivering the cases.

To accomplish the difficult task of setting up and restoring these groups, the services of Mr B. M. Hartley, of New Haven, were obtained. During the four months he was at the Museum, the damaged and dismantled groups were put in shape again and two large nesting groups (goshawks and duck hawks) were prepared from material previously acquired from the collection of Mr S. H. Paine, of Silver Bay, and other smaller exhibits were finished. The skeleton of the finback whale was assembled and hung in the zoology hall by Mr C. E. Mirguet, of Washington, by whom the skeleton was originally mounted.

One of the important parts of the year's work was in adding to the equipment of the taxidermist's room so that the work of preparing the specimens and accessories for the bird and animal groups could be carried on. The water power air compressor used in Geological Hall proved a failure in the new quarters because of its worn-out condition and because of the lower water pressure in its new location, and has been replaced with a much more powerful portable electric compressor which will be available for a great variety of uses. Other needed additions to the taxidermist's outfit, notably a carpenter's work bench, a drill press and other tools, a galvanized iron box and cover for the relaxing chest and a wooden tank for preserving fluid were also made.

The collection of birds' eggs and nests has been sorted out, cataloged and so packed that the specimens suitable for exhibition will be easily accessible. The alcoholic material has been gone over and cared for, and made accessible for study and comparison. Though useful for such purposes, it is not for the most part of a character desirable for exhibition. It will be kept in storage cases in the zoologist's room, and specimens prepared in ways more attractive to the public will be used for exhibition.

Under the conditions that have prevailed, it has been impossible to devote much time and money to increasing the collections, but a number of important additions to the exhibition collections of mammals, birds, birds' nests and eggs and fishes have been received, notably a pair of pumas and a pair of fishers previously ordered from Ward's Natural Science Establishment and a number of native fishes obtained in the local markets and mounted by the museum taxidermist. The most valuable single specimen received is the skin of a large buffalo bull from the Blue Mountain Forest Preserve, presented by Mr Austin Corbin, which has been mounted at Ward's

Digitized by Google

Natural Science Establishment and will be used in a group with several other specimens already in our possession.

Birds of New York. The completed text of volume 2 of Birds of New York, the publication of which has been delayed on account of the illness of Professor Eaton, the author, was sent to press in the summer and it is expected will be ready for delivery by the first of May or June. This volume covers the land birds and, as the game and water birds were included in volume 1, the completion of the work in hand as volume 2 of Museum Memoir 12, will bring to an end the present representation of all species of birds occurring in the fauna of New York, including visitants and migrants, with a complete illustration in color of every species. Volume 1 was received with such general approbation and appreciation, it is believed that volume 2, which covers the birds coming under more general daily observation of the larger public, will meet even a greater need than its predecessor. Volume 2 carries, besides the descriptions and illustrative matter, a series of general chapters on the habits and general ecological relations of birds and the part they play in human society and culture. Occasion is taken at this time to make announcement of the fact that volume 1 was offered to the public at $3 a volume; volume 2, which is somewhat larger than volume 1, carrying more text matter and a greater number of color plates, will be sold at the same price to all who have received volume 1, but otherwise at $4.

Monograph of the New York mollusca. The work of preparing the monograph of the New York mollusca, which is in the charge of Dr H. A. Pilsbry of the Philadelphia Academy of Sciences, has gone forward and the author reports an increasing number of illustrations made, together with the preparation of considerable additional text matter. It is probable that the entire work will be brought to completion within the coming year.

Myriapods of New York. The late Frederick C. Paulmier, while zoologist of the Museum, prepared and annotated a checklist of the myriapods of New York, and this list was supplemented by notes and memoranda, together with an index of the genera, made by Professor George H. Chadwick while occupying the same position on the Museum staff. It has seemed well to bring this undertaking to completion and Dr Roy W. Miner of the American Museum of Natural History has very kindly consented to take over the manuscripts and memoranda with the purpose of putting them in final form as an illustrated compendium of these animals as they occur in the State.

Digitized by Google

VI

REPORT OF THE ARCHEOLOGIST

The fiscal year ending September 30, 1913 has been unusual in the history of the archeology section of the State Museum. During the year the general display cases for archeological and ethnological material have been installed, but the large group cases for the ethnological series of Iroquois culture phases have reached only the stage of plans. This circumstance prevents any definite attempt to fill the other cases, so soon to be moved, rearranged and covered during the building of the group cases. A temporary display of the ethnological material, however, demonstrated that the archeological and ethnological divisions will be cramped for exhibition room unless the greater portion of the eastern mezzanine hall is taken over for a hall of comparative and special area archeology. Plans have already been made to fill this hall with archeology cases.

From the Museum rehabilitation fund several important collections of archeological specimens have been acquired. This encouraging fact again makes the State Museum the repository of an extraordinary collection of cultural artifacts of the New York aborigines. Through careful purchases and wise selections of large collections from special localities, the archeological series will surpass the former exhibit destroyed in the Capitol fire. The more adequate means now at hand for exhibiting these specimens will make possible an exhibit of vast importance. Definite plans have already been drawn up in view of a scientific display of these artifacts.

It must be definitely understood that, in the vulgar sense, no relics or curios will be exhibited. The curious object devoid of adequate data will have no room in these cases, the plan being to show visually the arts, industries, crafts, ceremonies, means of livelihood and burial customs of the race or races, tribes and nations that preceded the white man in the occupation of this territory. The plan is to make an educational exhibit of culture history and culture development. The collections as exhibited must live, in the sense of being valuable modes of instruction in the prehistory of New York. All the various collections acquired have been thoughtfully studied with this object in mind. It is hoped this plan, when carried out, will establish the educational value of the archeological exhibits. We have the material, though it is highly

Digitized by Google

desirable that it be constantly added to, for it is by no means as yet complete.

The special interest inherent in this collection is that we are able to link the aboriginal period through its gradual stages of transition to the Indians still living in the State today. Valuable collections like that acquired from Raymond C. Dann of Fairport show the Seneca culture at an interesting period of transition. The so-called "stone age" is linked with the "age of iron."

Collections purchased. During the year the Archeologist visited all the principal collectors who had indicated a willingness to sell their specimens to the State Museum. This examination has led to the acquisition of the following collections:

	Number of specimens
R. D. Loveland, Watertown	1965
Charles P. Oatman, Liverpool	775
Alva S. Reed, Livonia	646
Ward E. Bryan, Elmira	1092
R. E. Van Valkenburg, Mount Upton	331
C. A. Holmes, New Berlin	652
Raymond G. Dann, Fairport	1662
Frederick H. Crofoot, Sonyea	9647
Smaller collections	600
Total	17370

The localities represented are the territory adjacent to the eastern end of Lake Ontario, the upper waters of the Hudson, the Chenango valley, the southern end of Canandaigua lake, the valley of the Susquehanna near Elmira, the Genesee valley and the various sites in Ontario and Monroe counties. Other collections from important centers are under consideration. The material so acquired does not represent merely surface finds, for the Reed, Oatman, Loveland and Dann collections are largely the result of excavations.

To describe in detail the various collections acquired during the year would be a lengthy task and require much special study involving a considerable period of time.

For the purposes of a general report, the sketches of each collection as found below will be sufficiently descriptive.

The Raymond Dann collection results from excavations made on the John Dann farm three-fourths of a mile south of Honeoye Falls, Monroe county. The site lies along Totiacton creek and covers a large acreage, probably 30 or 40, with scattering evidences of occupation all about. Here, during the third quarter of the 17th century, was a large Seneca village and graveyard. Mr John Dann believes

Digitized by Google

Animal effigy pipes from the Dann Collection, Honeoye Falls. The two larger pipes at the top have brass or copper eyes

Digitized by Google

Digitized by Google

Types of pipes from the Dann Collection, Honeoye Falls

Digitized by Google

Digitized by Google

Clay vessels with ears from the Dann Collection, Honeoye Falls

Digitized by Google

Digitized by Google

this site to be one of the several Totiacton villages. There is every evidence of a continued contact with Europeans and the artifacts of the so-called stone age mingle with those of European manufacture, such as brass, iron, lead, crockery, glass and bone.

Much of the material came from refuse pits and dumps, but by far the greater portion was taken from the numerous graves on the sloping hillside. The objects found by Mr Dann were carefully cataloged, giving thereby an added value. An interesting variety of pipes is contained in this collection. Of greater interest, however, is the fine collection of pottery vessels, some of which have unique features, for instance, handles or ears. Among the shell ornaments are many quarts of wampum beads, many effigies, disks, crescents and cylindrical and spheroidal beads. The bone implements include a fine series of combs having figures carved at the top, awls, effigy figures of the human form, cylindrical beads and tortoise carapaces. The stone implements include the usual array of flints, anvils, hammers and pitted stones.

The proof of European contact is found in the European wampum, glass beads, objects of brass (as kettles, chains etc.), iron knives, lead and pewter.

By this collection it is possible to illustrate the art of the Senecas in all the various substances in which they wrought and then to show side by side the objects brought by the traders to supplant the native artifacts. The goods of the white man were superior and were therefore eagerly sought. Native industries gradually decreased and they became dependent upon implements and utensils that they themselves did not and could not produce. A temporary arrangement of the Dann collection illustrates this, showing the decadence of native art and industry resulting from contact.

An earlier Seneca site is illustrated by the Alva Reed collection. This collection is the result of digging into the refuse pits and side hill dumps of an ancient Seneca stronghold near the town of Richmond Mills, Ontario county. The site is upon a high hill overlooking the Hemlock valley. The site itself is well protected by the high walls of a creek on one side, a long slope on the west side and a ravine to the south. There are indications of palisades that still further protected the place. No graves have been found on this site although on one of our surveys we found human remains near the surface in the stiff clay at the upper end of the " fort." Graves were later found across the ravine by Frederick Houghton, but no objects other than human bones were discovered in the graves.

Digitized by Google

Mr Reed, who made the collection through many years of digging at his leisure hours, has been careful to collect and catalog with method. He found no objects of European manufacture and no signs that the occupants of what he terms "the old fort" had ever seen the white man. The collection embraces good series of shell, bone, antler, stone and clay objects. It is especially rich in fine bone implements and early shell ornaments. The pottery unfortunately is mostly fragmentary. The special value of this collection lies in the fact that it may with reasonable certainty be called precolonial Senecan. It is therefore a good type-collection of this period and is valuable as a base for comparison.

A mixed collection from Livingston county is that made by Mr Fred H. Crofoot of Sonyea. It is the result of a surface examination of some forty sites up and down the Genesee valley from the Honeoye Junction to Mount Morris, and of all the tributaries within this region. Many stages of occupation are represented and occupations beginning with the Esquimaux-like through the early Algonkian, the mound culture, the later Algonkian, the early and later Iroquoian into the colonial period.

One of the thickly populated centers of the early Iroquoian peoples is the area bounded on the west by the east shore of Lake Ontario and on the north and northeast by the St Lawrence. This geographical area is embraced in the present county of Jefferson. Here have been a succession of occupations with the precolonial Iroquois leaving the greater portion of cultural artifacts. Several large collections have been made there, with those made by R. D. Loveland and Charles Oatman leading in objects of interest. Earlier small collections are those made by Dr R. W. Amidon, Doctor Getman and Captain Oldham. The Museum acquired these smaller collections between 1906 and 1909. This year the Museum has been enabled to obtain both the Loveland and Oatman collections. Each collection is rich in fine examples of clay pipes, more than 250 being embraced in both. Some have been carefully restored from the broken fragments, thus showing almost exactly the original forms. The range of ornamentation and relief decoration is wide and on the whole is consistently Iroquoian. No entire clay vessels were found in this locality, but the collections contain thousands of valuable fragments. Bone and antler objects are numerous and of good quality.

From the region drained by the Susquehanna and its tributaries we have acquired three small but not unimportant collections —

Digitized by Google

Antler combs and effigies from the Dann Collection, Honeoye Falls

Digitized by Google

Digitized by Google

Antler combs from the Dann Collection, Honeoye Falls

Digitized by Google

Digitized by Google

those of Ward E. Bryan of Elmira, R. E. Van Valkenburg of Mount Upton and C. A. Holmes of New Berlin. Here, as might be expected, are many evidences of Algonkian occupation. Some of the specimens appear to be early types as illustrated by the weathered argillete and limestone chipped implements.

Mr D. D. Luther during the year sent in 440 specimens from an early Algonkian site near Naples, Yates county. Although

STONE FACE FROM CHEMUNG COUNTY

many of the specimens are fragmentary, for purposes of comparison the collection is highly interesting. It was through Mr Luther that the Museum has acquired the fine objects from the site near Middlesex. These specimens are largely tablet gorgets, stone tubes, shell beads and a copper implement. The burials appear similar in type to a certain Ohio culture.

Ethnology. Two trips were made to the New York reservations and some valuable specimens of historic Iroquoian art obtained.

Digitized by Google

Among these specimens were ceremonial objects of the Eagle or Bird dance, dance rattles and paraphernalia, carved bowls, wood spoons and similar ornaments. Decorated clothing was obtained at Allegany and husk objects, notably moccasins, at Cattaraugus.

Year by year the native artifacts used by the Iroquois of New York and Ontario are diminishing in number and variety. Makeshifts are frequently employed, as for example, tin can rattles for horn rattles, fringed canvas masks for corn-husk masks and a tin dipper for the ceremonial ladle. Only a few old persons remain who remember the ancient arts of weaving and quill decoration. Thus the field is constantly growing more barren and it is only with great effort, combined with good fortune, that desirable objects of ethnological interest are obtained. Flying trips on the reservation are not satisfactory means of collecting. A residence of several months for the express purpose of collecting specimens will be found more conducive of results. Thus the short time actually devoted this year to collecting was remarkably productive.

As is customary, this year some effort was made to add to our store of folk tales, myths and texts, but little time could be given to this task. Some corrections to manuscripts already at hand were made. Our important manuscripts on Iroquois ethnology must receive early attention with the idea of a thorough revision and publication. Students of ethnology in general eagerly await the facts that we have to give. The amount of work ahead in this direction alone represents much activity and time for the future.

Public interest. It is gratifying to note the increasing value of this section of the Museum to the public. Although the accessions are not yet on exhibition, numerous students make personal visits and the specimens are made available for study. The specially valuable locality collections afford a unique means for comparison. Distribution of types and specimens may be studied here as in no other institution. The gradual realization of these facts is constantly bringing inquiries relative to the aboriginal occupation of the State.

Numerous letters are received requesting information on various subjects, such as the history of the New York Indians, myths, games, customs, rituals, religion, language, names, music, present condition, distribution etc. etc.

Many requests have come for accurate and appropriate Indian names. The intended use of these names has ranged from names for camp fire girls clubs, estates and boats, to names for lakes, hills, springs, and other geographical features. At the request of Hon.

Digitized by Google

George Foster Peabody, State Commissioner of Saratoga Springs, appropriate Indian names were selected for certain springs at Saratoga. These names are from the Algonkian or Iroquoian languages and may be verified as correct by any student of these tongues.

The publications relating to archeology and ethnology continue to be in demand. The public call has exhausted the supply of several of these bulletins.

The degree with which this section of the Museum may be useful as a source of information is shown by the very active interest taken by educators, historians, ethnologists, sociologists and writers of fiction, in the Iroquois confederacy. Scarcely any one of these refers to the colonial history of New York without weaving in the history of the Iroquois league and its unique influence. Our archeological and ethnological sections have thus become sources of information and as this fact becomes better known, are attracting increasing attention. The completion of the Museum exhibits will naturally stimulate this interest to the highest degree.

NOTES ON CERTAIN ACQUISITIONS

From Irondequoit creek has come a unique clay pipe. It was collected by Mr B. Benro and acquired through the courtesy of Frank H. Ward of Rochester. Mr Benro found it protruding in the bank of the creek about 3 feet below the surface. The form of the pipe as shown in the accompanying figure is like that of a flattened war club or stone axe handle. It is flattened on each side with a curved surface on the back side (away from the smoker). The material is a compact clay, well baked and tempered with sand containing mica. There is a fracture in the pipe just below the curve, and the nipple or mouthpiece has been broken off. The decoration is the familiar angular pattern made by filling the triangles with parallel lines, using one side of the triangle as the base parallel. Short lines more deeply incised, or long dots, are found at each end of these triangles and seem to represent the stitching of quills on birch bark. There is a stitched seam on the front (toward the smoker) of the pipe, near the left side. The back and left side of the pipe are more neatly decorated, as if done first. The top edge of the bowl is decorated on the back and two sides with three parallel lines at the edges of which are "long dots" or "stitch markings."

The bowl is about 2¾ inches deep and extends to the bend. The capacity of this bowl is greater than the usual Iroquois pipe.

Digitized by Google

The pipe is so balanced despite its bend that it will stand upon its bowl. In a collection of several hundred Iroquoian pipes in the State Museum, none approaches the Irondequoit pipe in form.

Some very fine specimens of pre-Iroquoian art have come to the Museum from the eastern shore of Canandaigua lake. The site

THE IRONDEQUOIT PIPE

covers a small hillside and consists of an ancient burial plot, though the skeletons are not placed in any degree of regularity, as to location, nor are the graves numerous. The culture represented is similar to that of the mound-building Indians of New York and Ohio.

Digitized by Google

String of shell beads, elk teeth and shell disk from a site in Middlesex on Canandaigua lake

Digitized by Google

Digitized by Google

Articles from Middlesex site. Stone tubes, broken amulet, crude clay pipe, bar-amulet, stone tube

Digitized by Google

Digitized by Google

Articles from the Middlesex site. Bone pendant, antler awl, slate gorget, copper chisel and portion of ivory dagger blade

Digitized by Google

Digitized by Google

Artifacts from this culture are found in certain portions of New York State but usually associated with small mounds or stone graves. The State Museum has records of several such sites but unfortunately has never been able to excavate one. No trained observer has watched or recorded these accidental finds. It is to be hoped that in the future it may be possible to supplement the bare objects with their meager data of discovery, by excavating such sites under scientific oversight.

In one grave opened up in a gravel bank, near Middlesex, two entire stone tubes and one broken specimen were found. With these was a crude clay pipe with a short stem and small bowl, an awl lance head of antler, a bone pendant and a small copper chisel.

In another grave opened this year was a large black slate gorget of the two-hole type, a double-tailed "bird stone" and the middle portion of a dagger or blade made of mastodon tusk. No other specimen made of such material has been found in the State, as far as is known to the Museum. The gorget is one of the largest in our collections, measuring 6 inches in length, 4 inches in width at top and 3½ inches at the bottom. The sides are only slightly convex, but both top and bottom are arcs of circles. The central point of each arc is the perforation most distant from it. The center of each hole is equidistant from the edge immediately below it. The perforations are all so exactly placed on the gorget that each is the midway point in a line drawn perpendicularly.

The gorget seems to be divided in approximate fifths with each hole at a point from each end, about two-fifths of the length. The distance between the holes is $1\frac{5}{16}$ inches. These measurements are given only for the sake of description to show the exactness with which the specimen was made. The surface is covered with arborescent crystals of some carbonate, though originally there was a high polish.

The range of pipe forms and pottery as illustrated by the specimens from Jefferson county and contained in the Oatman and Loveland collections, presents a fairly good view of precolonial Iroquoian ceramic art. The pipes are of especial interest because they break away from purely utilitarian forms in outline and conventional decoration. The modeling on many represents human and animal forms, sometimes quite natural, and in other instances conventionalized.

The Iroquoian clay pot, judged by the specimens in these collections, is usually a fine piece of work, in the sense that the clay has been carefully prepared, tempered and modeled. Iroquois

Digitized by Google

pottery in texture and durability is superior to Algonkian pottery. The body of the pot, in general, is that of a flattened globe with a constructed neck that flares into a wide collar, either round or, more generally, squared with upward projecting tips at each corner. This collar is generally decorated with triangular patterns made of parallel lines. Some of the older potsherds show cord or paddle markings all over the outer surface.

The parallel lines in triangular patterns seem to imitate porcupine quill decorations on birch bark and indeed the form of the pot seems to follow the stitching of a birch bark receptacle. The dots or indentations about the base of the neck indeed seem to point out the place where the upper portion of the bark collar was sewed to the lower portion. This idea was suggested in the early writings of Frank Cushing. As far as has been discovered, however, the New York Iroquois did not use birch bark receptacles. Theirs were of elm bark, a much rougher material but more durable. No circular or curved designs are found on Jefferson county Iroquois pottery, the only exception being round dots, punched on, singly or in angular patterns. Jefferson county Iroquois pipes of clay are superior to any found among contiguous stocks. They were molded with their stems and were not designed for long wooden stems. There are several types of pipes as may be seen on the accompanying plate. The simplest forms are the trumpet "pipe" and the pipe with the collar about the top of the bowl, composed of several parallel rings, like coiled cord. Other forms are the square topped pipe, the so-called Huronian, and pipes with human and animal effigies on the bowls. These effigy pipes in concept and form oddly resemble the pottery of the Mississippi valley. The caps shown on the heads of effigies are shaped like the old-fashioned beehive. Even designs of face painting are shown and the bear or wolf skin robe is shown over the Indian's head.

Trumpet bowls are found on the early Erie, Onondaga and Mohawk sites, and ringed collar is found on Seneca, Neuter and Huron sites.

Strangely, Iroquois stone pipes are not similar to their clay pipes. As far as decoration and modeling are concerned, they might have been made by another stock. There may be a few exceptions, but in general, the rule applies. An example is the long-tailed animal effigy pipe bowl, studied with much care by Lieutenant G. E. Laidlaw, and reported in the publications of the Ontario Provincial Museum. Many of these stone pipes appear to have been carefully kept; possibly they expressed the art of the earlier Iroquois and were kept as ceremonials or as heirlooms.

Digitized by Google

Clay pipes from Jefferson county. Loveland Collection

Digitized by Google

Digitized by Google

VII

PUBLICATIONS

A list of the scientific publications issued during the year 1912–13, with those now in press and treatises ready for printing, is attached hereto. The publications issued cover the whole range of our scientific activities. They embrace 1391 pages of text and 184 plates.

ANNUAL REPORT

1 Ninth Report of the Director, State Geologist and Paleontologist for the fiscal year ending September 30, 1912. 214p. 50pl.

Contents

Introduction
I The State Museum law
The statutory conception of a "State Museum"
The State Museum idea and its place in the polity of the State
II The educational function of the State Museum of Science
III Condition of the scientific collections
IV Report on the geological survey
Areal geology
Surficial geology
Industrial geology
Seismologic station
Paleontology
V Report of the State Botanist
VI Report of the State Entomologist
VII Report of the Zoologist
Monograph of the New York Mollusca
VIII Report of the Archeologist
Archeological survey
The O. W. Auringer collection
Archeological collections
Folklore
Public interest
IX Publications
X Staff of the Science Division and State Museum
XI Accessions
The Mount Morris Meteorite. H. P. WHITLOCK
Early Paleozoic Physiography of the Southern Adirondacks. W. J. MILLER
The Garnet Deposits of Warren County, New York. W. J. MILLER
The Use of the Stereogram in Paleobiology. G. H. HUDSON
The Origin of the Gulf of St Lawrence. J. M. CLARKE
A Notable Trilobite from the Percé Rock. J. M. CLARKE
Illustrations of the Devonic Fossils of Southern Brazil and the Falkland Islands. J. M. CLARKE
Index

Digitized by Google

MEMOIRS

Paleontology

2 The Eurypterida of New York. By John M. Clarke and Rudolf Ruedemann. 1912. 2 vols. 628p. 88pl.

Contents

Preface
Introduction
History of investigations
Eurypterida I Morphology, anatomy, and terminology
II Mode of life
III Geological distribution and bionomic relations
A Conspectus of American species arranged according to their geological occurrence
B Biologic facies of the eurypterid faunas
Eurypterida III
C Geological distribution in other countries
D Bionomy of the eurypterid faunas
IV Ontogeny
V Phylogeny
VI Taxonomic relations
VII Synoptic table of North American Eurypterida
VIII Systematic account of the Eurypterida
Eurypteridae
Pterygotidae
Appendix
Bibliography

BULLETINS

Geology and Paleontology

3 No. 162 The Lower Siluric Shales of the Mohawk Valley. By Rudolf Ruedemann. 1912. 151p. 15pl.

Contents

Introduction
Historical sketch
"Utica" shale of authors
Frankfort shale
Schenectady formation
Indian Ladder beds
Summary
Bibliography
Paleontological notes
Explanation of plates
Index

4 No. 166 The Mining and Quarry Industry of New York State. By D. H. Newland. 1913. 114p.

Contents

Introduction
Mineral production of New York
Cement
Clay
Production of clay materials
Manufacture of building brick
Other clay materials

Digitized by Google

Pottery
Crude clay
Emery
Feldspar
Garnet
Graphite
Gypsum
Iron ore
Mineral waters
Natural gas
Petroleum
Pyrite
Salt
Sand and gravel
Sand-lime brick
Stone
Production of stone
Granite
Limestone
Marble
Sandstone
Trap
Talc
Zinc
Index

Archeology

5 No. 163 The Code of Handsome Lake, the Seneca Prophet. By Arthur C. Parker. 1913. 144p. 23pl.

Contents

Introduction
Handsome Lake
Effects of Handsome Lake's teaching
How the white race came to America
The Gaiwiio code
Sections 1 to 130: The Great Message
Part 2. Field notes on rites and ceremonies
White dog sacrifice
Ganeowo
Cornplanting and maple thanksgiving
Legend of the coming of Death
The funeral address
The death feast
Medicine societies
Dark dance or pygmy ceremony
Society of otters
Society of mystic animals
The eagle society
The bear society
The Buffalo society
Chanters for the dead
Woman's society
Sisters of the Dio' hë'ko
False face company
Husk faces
Iroquois sun myths
Anecdotes of Cornplanter
Key to pronunciation
Index

Entomology

6 No. 165 Report of the State Entomologist for the fiscal year ending September 30, 1912. 1913. 264p. 14pl.

Contents

Introduction
Injurious insects
Codling moth
Hessian fly
Fall army worm
Elm leaf beetle
White grubs and June beetles
Hickory bark borer
Pear thrips
Queen blow fly
Georgian flesh fly
Use of oil on dormant trees
Notes for the year
Fruit tree insects
Forest insects
Miscellaneous
Publications of the entomologist
Additions to collections
Appendix: a study of gall midges
Explanation of plates
Index

Digitized by Google

Botany

7 No. 167 Report of the State Botanist for the fiscal year ending September 30, 1912. 1913. 76p. 4pl.

Contents

Introduction
Plants added to the herbarium
Contributors and their contributions
Species not before reported
Remarks and observations
New species of extralimital fungi
Edible fungi
Poisonous fungi
Crataegus in New York
Explanation of plates
Index

In press

MEMOIRS

8 Birds of New York, volume 2

BULLETINS

Geology and Paleontology

9 The Geological History of New York State
10 Geology of Saratoga Springs and Vicinity
11 Geology of the North Creek Quadrangle
12 Geology of the Attica-Depew Quadrangles
13 Geology of the Syracuse Quadrangle

Entomology

14 Report of the State Entomologist for the fiscal year ending September 30, 1913

Digitized by Google

VIII

REPORT ON THE COLLECTION OF COINS, MEDALS AND PAPER MONEY

These collections, by action of the Regents, were transferred to the custody of the State Museum after the Capitol fire, and the following is a report on their present condition.

Catalog of 1856. The only existing record of this collection was issued by the State Library for the year 1856 (dated 1857). In this catalog the numerical contents of the collection are stated as follows: coins (all metals), 1697; medals, 234; paper money, 320.

Fire losses from the collection of 1856. A checking of the record of 1856 by an expert numismatist shows that of the materials above listed the following are the losses: coins, 897; medals, 197; paper money, all. The losses therefore were, for the coins over 50 per cent; medals, about 80 per cent; paper money, 100 per cent.

Coins not in the catalog of 1856. In the salvage from the fire there are, not recorded in the catalog of 1856, 2376 coins and 57 medals. The total number of coins and medals in the salvage is 3270.

General condition of the coin collection. The condition of this collection is bad. With the exception of a very few articles in gold which have been on deposit in the National Commercial Bank, Albany, since 1881, nearly every specimen has suffered, and the majority of them irreparably. This has been due in the first instance to oxidation and discoloration in fire, aggravated by improper treatment of much of the material when first rescued.

Value of this collection. On an expert estimate of the face value of all the coins and the market value of all United States coins, it appears that the face value of the entire collection is approximately $725; that the market value of the *American coins* of all metals is $499.

General character of the collection. This collection is composed of a small number of gold coins and medals of considerable worth, most of them of American coinage, but some of other countries; a large number of silver coins in rather bad condition, and a very great majority of copper coins from all countries of the world and of very little worth. The value of the collection (such as it is) lies in its *United States coins and medals*, very few of which are of superior quality or great rarity. These total about 1500.

Digitized by Google

Alternative suggestions in regard to the coin collection. These suggestions are of necessity based on the recognized demoralized condition of the collection and are submitted without recommendation. Attention, however, is invited to the fact that this collection has evidently been largely made without any or only very occasional expenditures of State moneys. They have come by gift and it is very probable that like gifts will continue, especially of commemorative medals struck in this and other countries. It would seem that the University should be at least receptive of such gifts whether or not expenditures for the collection be approved.

1 Any action whatever regarding the collection may be suspended and the collection kept as it is at the present time, subject to additions by gift.

2 The collection might be sold as a whole, with the specific permission of the Legislature, the returns therefor to revert to the State treasury.

3 The collection might be deposited on temporary or permanent loan with any society that the Regents might choose to designate, subject to the permanent supervision of the collection by the Board of Regents.

4 *Gift.* It appears very doubtful, in the opinion of the law officer of the Department, whether even the Legislature could empower the Board to dispose of the collection by gift.

5 *Possibility for the development of the collection.* It may be worth while to consider whether it would not be a proper policy to maintain and build up a representative collection of American coinages. The nucleus therefor now in the custody of the Board is considerable in number although it lacks in quality that which would be required by the connoisseur. Still these examples of American coinages are of such a kind as to indicate satisfactorily their varieties, so far as these extend. Very slight occasional expenditures could be made to acquire additional material and the balance of the collection, not American, could be utilized by way of exchange for the purpose of acquiring solely American coins. Should this suggestion seem a reasonable one, it is well to supplement it by recognition of the evident fact that there is a large degree of public interest in American coinages and that it might be the people of the State may desire to have here in the Regents' custody a representative array of such coins which could be made accessible to students for purposes of comparison and study. The possibility of converting all the other parts of the entire collection into substantial support for the enlargement of the American collection would seem to give this suggestion reasonable encouragement.

Digitized by Google

IX

STAFF OF THE DEPARTMENT OF SCIENCE

The members of the staff, permanent and temporary, of the Department of Science as at present constituted are:

ADMINISTRATION

John M. Clarke, Director
Jacob Van Deloo, Director's Clerk
Paul E. Reynolds, Stenographer

GEOLOGY AND PALEONTOLOGY

John M. Clarke, State Geologist and Paleontologist
David H. Newland, Assistant State Geologist, *Curator of Geology*
Rudolf Ruedemann, Assistant State Paleontologist, *Curator of Paleontology.*
C. A. Hartnagel, Assistant in Geology, *Curator of Stratigraphy*
Robert W. Jones, Assistant in Economic Geology, *Assistant Curator of Industrial Geology*
D. Dana Luther, Field Geologist
Herbert P. Whitlock, Mineralogist, *Curator of Mineralogy*
George S. Barkentin, Draftsman
H. C. Wardell, Preparator, *Assistant Curator of Paleontology*
John J. Bryan, Stenographer
Charles P. Heidenrich, Mechanical Assistant
Joseph Bylancik, Page

Temporary experts

Areal geology

Prof. H. P. Cushing, Adelbert College
Prof. C. H. Smyth, jr, Princeton University
Prof. James F. Kemp, Columbia University
Prof. W. J. Miller, Hamilton College
Dr C. P. Berkey, Columbia University
G. H. Hudson, Plattsburg State Normal School
Dr W. O. Crosby, Massachusetts Institute of Technology
Prof. George H. Chadwick, St Lawrence University
James C. Martin, Princeton University

Geographic geology

Prof. Herman L. Fairchild, University of Rochester
Prof. James H. Stoller, Union College

Digitized by Google

Paleontology

Edwin Kirk, Washington, D. C.

BOTANY

Charles H. Peck, State Botanist
Homer D. House, Assistant, *Curator of Botany*

ENTOMOLOGY

Ephraim P. Felt, State Entomologist
D. B. Young, Assistant State Entomologist, *Curator of Entomology*
Fanny T. Hartman, Assistant, *Assistant Curator of Entomology*
Anna M. Tolhurst, Stenographer
Charles W. Swim, Clerk

ZOOLOGY

Willard G. Van Name, Zoologist, *Curator of Zoology*
Arthur Paladin, Taxidermist

Temporary experts

Prof. E. Howard Eaton, Canandaigua
Dr H. A. Pilsbry, Philadelphia
Charles E. Mirguet, Rochester
B. M. Hartley, West Haven, Conn.

ARCHEOLOGY

Arthur C. Parker, Archeologist, *Curator of Archeology and Ethnology*
Noah T. Clarke, Technical Assistant, *Assistant Curator of Archeology and Ethnology*

Temporary assistant

Howard A. Lansing, Albany

Digitized by Google

X

ACCESSIONS

ECONOMIC GEOLOGY

Collection

Newland, D. H. Albany

Building stones from southeastern New York	5
Feldspar crystallized and massive, Bedford	3
Large beryl crystal, Bedford	1
Ground feldspar, Bedford	1
Molding sands from Albany and Rensselaer counties	15
Red slate, with quartz veinlets, Washington county	1
Iron ores and wall rocks, Adirondacks	20
Anorthosite, building stone, Keeseville	5

Jones, R. W. Albany

Clay, sand and brick, Mechanicville	5
Fire clay, Shenandoah	2
Talc, Shenandoah	2
Paving and building bricks, clays etc., Corning	13
Molding sands, Albany and Greene counties	2
Evaporated salt, Ithaca	3
Cement and cement materials, Portland Point	6
Sand-lime brick and raw materials, Glens Falls	3
Building brick and crude clays, Glens Falls	8
Building bricks, raw materials, etc., Troy	15
Clays, sands and brick, Kreischerville	21
Clays, sands and brick, Long Island	20
Building brick, drain tile, etc., Albany	19
Feldspar, quartz and beryl, Bedford	9
Emery and garnet, Peekskill	5
Natural cement and cement rock, Kingston	7
Paving and building brick, Catskill	4

Donation

Onondaga Coarse Salt Association. Syracuse

Exhibit of solar salt	7

International Acheson Graphite Co. Niagara Falls

Artificial graphite	11

The Carborundum Co. Niagara Falls

Exhibit of carborundum, aloxite, emery etc	25

Digitized by Google

Alpha Portland Cement Co. Cementon, Pa.
Exhibit of cement and cement materials..... 9
Clinton Metallic Paint Co. Clinton
Metallic Paint 2
Furnaceville Iron Co. Ontario Center
Samples of Clinton ores..... 2
Alpha Portland Cement Co. Martin's Creek, Pa.
Portland cement and raw materials..... 7
Glens Falls Portland Cement Co. Glens Falls
Exhibit of cement and cement materials..... 9
William Connors Paint Mfg. Co. Troy
Crude and finished mineral paints..... 6
Pepson, Charles. Albany
Old sewer tile from Phoenix Place, Albany..... 2
St Lawrence Talc Co. Natural Bridge
Crude and ground talc..... 3
Pass, James, Onondaga Pottery Co. Syracuse
Exhibit illustrative of pottery manufacture..... 31
Emerson-Norris Co. New York
Artificial stone from Tuckahoe marble..... 6
Norton Company. Worcester, Mass.
Exhibit of alundum, crystolon etc., from plants at Niagara Falls 36
United States Gypsum Co. Chicago, Ill.
Exhibit of gypsum and gypsum products from Oakfield... 14
German Kali Works, Inc. New York
Specimens of German potash salts, including hartsalz, sylvinite, kainite and carnallite..... 20
Cheever Iron Ore Co. Port Henry
Iron ore, concentrates and tailings..... 3
Benson Mines Co. Benson Mines
Iron ore, concentrates and tailings..... 3
Hinckley Fibre Co. Hinckley
Pyrite from Cole mine, St Lawrence county..... 1
Atlantic Terra Cotta Co. New York
Architectural terra cotta, Staten Island plant..... 12
New York State Sewer Pipe Co. Rochester
Floor tiles, conduit and sewer pipe..... 9
St Lawrence Pyrite Co. De Kalb
Pyrite, crude ore and concentrates..... 6
Blake, P. X. Potsdam
Polished granite slab from Parishville..... 1

Digitized by Google

North River Garnet Co. North River
Garnet rock and garnet concentrates..... 4
Keystone Emery Mills. Frankford, Pa.
Crude and prepared emery from Peekskill..... 4
Witherbee, Sherman & Co. Mineville
Exhibit of ores, concentrates and tailings..... 10
Retsof Salt Co. Scranton, Pa.
Rock salt, crude and prepared..... 5
International Salt Co. Scranton, Pa.
Exhibit of brine salt..... 4
Asbestos & Asbestic Co. Ltd. Asbestos, P. Q.
Large blocks of serpentine veined with asbestos..... 2

GENERAL GEOLOGY

Collection

Clarke, John M. Albany
Calcite vein, faulted, Percé, P. Q..... 1
Jones, R. W. Albany
Weathered limestone and pegmatite, Shenandoah, N. Y. 3
Newland, D. H. Albany
Banded gneiss, Dublin, Westchester county..... 2
Folded and faulted Yonkers gneiss, Kensico..... 2
Graphic granite, Bedford..... 2

Donation

Kelley Island Lime & Transportation Co. Cleveland, O.
Large limestone slab, glaciated..... 1
Vermont Marble Co. Proctor, Vt.
Polished slab of faulted marble from True Blue quarry.. 1

MINERALOGY

Donation

Wait, Charles. Crown Point
Wernerite in calcite (large), Crown Point..... 1
Manchester, James G. New York City
Pectolite, apophyllite and stilbite (large), West Paterson, N. J..... 1
Clarke, John M. Albany
Halite, Alfeld, Prussia..... 1
Amphibole (Jade), locality?..... 1

Digitized by Google

Ruedemann, R. Albany

Gypsum, Brunswick, Germany..... 11
Celestite, Jena, Germany..... 2

Purchase

Law, E. S. Schenectady

Quartz on limestone, Sprakers..... 1
Quartz crystals, Sprakers..... 14

Foote Mineral Co. Philadelphia, Pa.

Stibnite, Iyo, Japan..... 1
Stibnite, Felsobanya, Hungary..... 1
Stibnite, Wuchow, China..... 1
Galena, Colquechaca, Bolivia..... 1
Galena, Benthen, Prussia..... 1
Galena, coated with marcasite, Prussia..... 1
Chalcopyrite on dolomite, Granby, Mo..... 1
Chalcopyrite on dolomite, Siegen, Prussia..... 1
Chalcopyrite and pyrite, Bingham, Utah..... 1
Chalcopyrite, Ugo, Japan..... 1
Pyrite, Saratoga mine, Col..... 1
Pyrite, Franklin, N. J..... 1
Pyrite, York county, Pa..... 1
Marcasite, Joplin, Mo..... 1
Marcasite altered to limonite, Richland county, Wis.... 1
Tetrahedrite, Kapnic, Hungary..... 1
Tetrahedrite, Felsobanya, Hungary..... 1
Tetrahedrite, Ouray county, Col..... 1
Rutile in quartz (polished), Japan..... 1
Corundum (sapphire), Butte, Mont..... 1 lot
Pickeringite, Tucumcari, N. M..... 1
Iron (Josephenite) water-worn pebbles, Oregon..... 1 lot
Sphalerite, translucent cleavage, Chivera, Mexico..... 1
Boulangerite, Oberlahr, Prussia..... 1
Anorthoclase (crystals), Sardinia..... 1 lot

Krantz, Dr F. Bonn, Germany

Calcite, St Goar, Prussia..... 1
Calcite, Andreasberg, Germany..... 1
Calcite with dolomite and quartz, Baden, Germany..... 1
Calcite, Pribram, Bohemia..... 1
Calcite (twinned crystals), Durham, England..... 1
Calcite (twinned crystals), Egremont, England..... 2

Digitized by Google

Calcite (large group), Egremont, England..... 1
Calcite (unique crystals), Egremont, England..... 1
Calcite (large crystals colored red), Egremont, England.. 1
Calcite (pyramidal crystals), Wisby, Sweden..... 1
Calcite (large group), Poretta, Italy..... 1
Calcite on quartz, Guanajuato, Mexico..... 1
Calcite (lilac colored), Guanajuato, Mexico..... 1

PALEONTOLOGY

Donation

Allardyce, Mrs Constance. Port Stanley, Falkland islands
Devonic fossils from Pebble island, Falkland islands.... 25

Grant, Colonel C. C. Hamilton, Ontario
Siluric fossils, Hamilton..... 8

Hobart College, The trustees of
(On indefinite loan) Castoroides ohioensis. The original skull described by Hall & Wyman and obtained in the pleistocene marshes near Clyde..... 1

Kelly, F. Helderberg Cement Co.
Trilobites from Howes Cave quarry..... 1

Moore, Prof. E. S. State College, Pa.
Graptolites from Spring Creek formation (Beekmantown) of Pennsylvania 6

Post, W. J. Harriman
Mastodon tusk found about 2 miles south of Harriman station (Erie R. R.), Orange co..... 1

Purchase

American Museum of Natural History. New York
Restoration of the skeleton of the Permic reptile Eryops. 1
Devonic fishes from Migouasha, P. Q..... 20

Gebhard, W. D. Schoharie
Collection of fossils from the Schoharie valley (Inventory to be given in next report)

Fink, Alvin J. Dayton, Ohio
Collection of trilobites..... 200

Kinnear, W. T. Kirkbuddo, Forfar, Scotland
Upper Siluric and Lower Devonic fishes from Scotland... 11

Krantz, Dr F. Bonn, Germany
European trilobites from various localities..... 25

Ward's Natural Science Establishment. Rochester
Proetus rowi from the Hamilton shales..... 1

Digitized by Google

Collection

Hartnagel, C. A.
Fossils from the Ordovicic-Siluric series of Arisaig, Nova Scotia 300

Exchange

Carnegie Museum (Dr C. R. Eastman)
Restorations of Devonic fishes..... 6

ENTOMOLOGY

Donation

Hymenoptera

Crawford, G. W. Ballston Spa. Lophyrus abbotii Leach, Abbott's pine sawfly, larvae on pine, October 1

Lossoe, F. R. Troy. Janus integer Norton, current stem borer on currant, February 21

Smith, F. A. Ticonderoga. Kaliofenusa ulmi Sund., European elm leaf miner, larvae on elm, June 4

Chase, F. Loon Lake. Hylotoma pectoralis Leach, birch sawfly, larvae on birch, July

State Department of Agriculture. Trichiosoma tibialis Steph., European hawthorn sawfly from England, cocoon on rose. November 27. Same as preceding, cocoon on barberry from Flushing, February 27

Bethel, E. Denver, Col. Aylax pisum Walsh, gall on Lygodesmia juncea, September 30

Gardner, Mrs E. P. Canandaigua. Through S. H. Burnham. Rhodites gracilis Ashm., regal rose gall, galls on Rosa blanda, September 29. Same as preceding, October 5. Also R. globulus Beutm., globular rose gall, gall on rose, October 5

Bethel, E. Manitou, Col. Myrmecocystus melliger Llave, honey ant, adult, November 30

Coleoptera

de Vyver, J. James. Bronxville. Eccoptogaster quadrispinosa Say, hickory bark borer, larvae on hickory. January 28

Matthiessen, C. H. Irvington. Corthylus punctatissimus Zimm., pitted Ambrosia beetle, adult on Rhododendron. September 13

Digitized by Google

Goodyear, Charles. Tarrytown. Same as preceding, work, October 1

Hilligas, William. Rensselaer. Cryptorhynchus lapathi Linn., mottled willow borer, grubs and work on poplar, June 18

Gillett, J. R. Kingston. Lixus concavus Say, rhubarb curculio, adult, March 31

Anderson, E. H. Mount Kisco. Pissodes strobi Peck, white pine weevil, work on pine, January 20

Pease, E. R. Poughkeepsie. Same as preceding, larvae and work on pine, July 14

Iceland, Mrs A. C. Middletown. Galerucella luteola Müll., elm leaf beetle, adults in house, May 28

Tilly, G. W. Mechanicville. Nodonota tristis Oliv., strawberry root worm, adult on strawberry, June 23

McDonough, W. F. Albany. Typophorus canellus Fabr., strawberry root worm, May 8

Sullivan, J. J. Valley Mills. Chrysochus auratus Fabr., gold gilt beetle, adults, November 6

Von Schrenk, Hermann. St Louis, Mo. Neoclytus erythrocephalus Fabr., adult and work on ash, September 3

Van Deusen, Mrs C. A. Hudson. Chion cinctus Dru., banded hickory borer, adult, March 16

State Department of Agriculture. Euphoria inda Linn., bumble flower beetle, adult on apple, September 4

Robertson, W. D. Rosyln. Allorhina nitida Linn., green June beetle, adult, July 3

Farrar, E. R. South Lincoln, Mass. Anomala lucicola Fabr., light-loving grapevine beetle, adult, July 7

Miller, W. S. East Greenbush. Lachnosterna fusca Froh., white grubs infested by the peculiar fungus, Cordyceps ravenelii Berk., February 14

Saugerties Manufacturing Company. Saugerties. Sitodrepa panicea Linn., drug store beetle, larvae, adults and work in account book, June 12

Coffin, C. A. Locust Valley. Agrilus ? bilineatus Web., two-lined chestnut borer, work on oak, October 30

Merkel, H. W. Scarsdale. Melanophila fulvoguttata Harr., spotted hemlock borer, larvae on hemlock, December 2

Downer, J. New York City. Same as preceding, January 30

Digitized by Google

Torbert, C. L. Syracuse. Same as preceding, bark of hemlock, May 16

McMillan, Charles. Cambridge. Dicerca divaricata Say, divaricated Buprestid, adult, June 20. Also Alaus oculatus Linn., owl beetle, adult, June 20

Titus, E. V. Glen Cove. Same as preceding, July 28

State Conservation Commission. Lake Clear. Anatis 15-punctata Oliv., 15-spotted lady beetle, adult on balsam, June 9

Lacky, Andrew. Johnsburg. Dytiscus harrisii Kirby, water beetle, adult, September 17

Diptera

Gillett, J. R. Kingston. Frontina frenchii Will., adults, March 31

Smith, W. F. White Plains. Bibio albipennis Say, white-winged Bibio, larvae on stable manure, March 28

Albright, Thomas. New Baltimore. Contarinia pyrivora Riley, pear midge, larvae on pear, May 7

Theobald, F. V. Wye, Kent, England. Same as preceding, adult, September

McAtee, W. L. Carlisle, Miss. Thecodiplosis ananassi Riley, galls and larvae on cypress, October 29

Garman, H. Louisville, Ky. Clinodiplosis florida Felt, gall on oak, May 27

Goodyear, Charles. Tarrytown. Same as preceding, June 13

Frost & Bartlett Co. Roslyn. Monarthropalpus buxi Lab., box leaf miner, larvae on box, August 21

Latham, Roy. Orient Point. Hormomyia crataegifolia Felt, coxcomb thorn gall, gall on Crataegus, August 12

Gardner, Mrs E. P. Canandaigua. Cincticornia pilulae Walsh, oak pill gall, gall on oak, October 5

McAtee, W. L. Riverdale, Md. Same as preceding, October 24

Shelter, Henry. Springwater. Schizomyia coryloides Walsh and Riley, clustered grape gall, gall on grape, August 8

Cosens, A. Toronto, Ont., Can. Lasioptera corni Felt, ocellate dogwood gall, gall on Cornus, September 21

Jackson & Perkins Company. Newark. Dasyneura rhodophaga Coq., rose gall midge, larvae on rose, July 16

Rorty, Mrs P. A. Goshen. Dasyneura communis Felt, galls on red maple, October 9

Digitized by Google

Garman, H. Lexington, Ky. Same as preceding, May 27

Bethel, E. Denver, Col. Rhabdophaga strobiloides Walsh, pine cone gall, gall on willow, September 30

Merkel, H. W. Scarsdale. Camptomyia tsugae Felt, larvae on hemlock, December 2

Siphonaptera

Sherwood, Miss Marcia J. Barker. Ceratophyllus gallinae Schrk., hen flea, adults in hens' nests, May 29

Heilman, J. R. Poughkeepsie. Ctenocephalus canis Curtis, house flea, adult, August 26

Lepidoptera

Goodyear, Charles. Tarrytown. Laertias philenor Linn., pipevine swallowtail, larva on Dutchman's pipe, June 24

Carl, Miss Nina. Breesport. Automeris io Fabr., Io caterpillar, larvae on sweet clover, August 27

Cushman, R. L. Yonkers. Same as preceding, larva on corn, September 4

Reed, C. M. Sinclairville. Halisidota caryae Harr., hickory tussock moth, larvae on hickory, September 27

State Department of Agriculture. Rochester. Peridroma margaritosa Haw., var. saucia Hubn., variegated cutworm, larvae on apple and grass, July 15

Bartlet, Miss Isabella M. New Hamburg. Xylina antennata Walk., green maple worm, larva on linden, May 19

Clark, C. A. Castleton. Same as preceding, larvae on apple, June 9

Von Schrenk, Hermann. St Louis, Mo. Papaipema ? merriccata Bird, stalk borer, larvae on May apple, May 13

Reed, C. M. Sinclairville. Datana integerrima Grote & Rob., black walnut caterpillar, larva on hickory, September 27

Heilman, J. R. Poughkeepsie. Schizura concinna Sm. & Abb., red-humped apple caterpillar, larvae, July 8

Carl, Miss Nina. Breesport. Hemerocampa leucostigma Sm. & Abb., white-marked tussock moth, larvae on wisteria, August 27

Levison, J. J. Brooklyn. Malacosoma disstria Hübn., forest tent caterpillar, eggs, December 17

Appleton, F. R., jr. Jericho. Through State Forester. Same as preceding, larvae on oak, May 26

Hechler, Charles. Roslyn. Same as preceding, May 30

Digitized by Google

Terry, S. S. Elizabethtown. Same as preceding, cocoons, June 21

Wynkoop, Irving. Granville. Same as preceding, larvae and cocoons on maple, June 23

Seely, J. A. Ogdensburg. Same as preceding, eggs on apple, September 5

Dunwald, Peter. Rio. Cladora atroliturata Walk., imago, April 11

Interstate Tree Treating Company. Mount Vernon. Anisopteryx pometaria Harr., fall canker worm, males, females and eggs, December 3

Dunwald, Peter. Rio. Phigalia titea Cram., imago on forest trees, April 11

Bartlet, Miss Isabella M. New Hamburg. Erannis tiliaria Harr., ten-lined inch worm on linden, May 19

Niles, H. W. Rye. Through State Department of Agriculture. Lagoa crispata Pack., flannel moth, caterpillar on apple, September 18

Cooper, Mrs E. H. Saratoga Springs. Acoloithus ? falsarius Clem., cocoons on Virginia creeper, September 5

Harris, A. G. Pelham. Zeuzera pyrina Linn., leopard moth, larva, May 31

Goodyear, Charles. Tarrytown. Same as preceding, larvae, September 4

Merkel, H. W. New York City. Sesia rhododendri Beutm., Rhododendron clearwing, work and larvae on rhododendron, September 29

Schoonmaker, C. B. Stone Ridge. ? Crambus caliginosellus Clem., larvae on corn, June 19

State Department of Agriculture. Westchester County. Pinipestis zimmermanni Grote, pine tip moth, work on Austrian pine, July 1

Eberle, F. W. Albany. Tinea granella Linn., European wolf moth, larvae on sweet corn, November 13

Ward, G. E. Ravena. Tmetocera ocellana Schiff., bud moth, larva on apple, April 16

Haney, Theodore. Ravena. Same as preceding, larva on apple, April 17

Jansen, C. B. Kingston. Same as preceding, larva on plum, April 26

Hunt, Fred. Kingston. Same as preceding, larva on pear, April 28

Digitized by Google

Vincent, H. B. Old Chatham. Same as preceding, April 30

St John, Clyde. Canajoharie. Same as preceding, May 15

Collamer orchard. Hilton. Through State Department of Agriculture. Archips argyrospila Walk., fruit tree leaf roller on apple, July 7

Lintner, George. Squirrel Island, Me. Tortrix fumiferana Clem., spruce bud moth, larva, adult and work on spruce, July 6

Gardiner, Mrs J. T. Northeast Harbor, Me. Same as preceding adults on spruce, July 15

Levison, J. J. Brooklyn. Eulia politana Haw., pine tube builder, work, November 12

Goodyear, Charles. Tarrytown. Coleophora limosipennella Dup., elm case bearer, work on elm, June 24

Albright, M. C. West Coxsackie. Coptodisca splendoriferella Clem., resplendent shield bearer, larvae and cases on apple, January 22

Hicks, Isaac & Son. Westbury. Argyresthia thuiella Pack., Arbor vitae leaf miner, pupae on Arbor vitae, June and October 4

Torbert, E. L. Syracuse. Phyllonoryter hamadryadella Clem., white-blotch oak leaf miner, larval mines on oak, May 28

de Vyver, J. James. Mount Vernon. Same as preceding, work on oak, October 22

Corrodentia

Gardner, J. H. Fort Covington. Caecilius pedicularius Linn., nymph and adult, October 14

Hemiptera

Miller, Mrs M. S. Boonville. Philaenus lineatus Linn., lined spittle insect on grass, June 23

Pierce, D. C. Hamburg. Through State Conservation Commission. Phylloxera caryaecaulis Fitch, hickory gall aphid, galls on hickory, June 20

Paine, H. S. Glens Falls. Same as preceding, July 10

Coffin, J. W. L. Katonah. Through State Conservation Commission. Chermes pinicorticis Fitch, pine bark aphid, adult on white pine, December 6

State Department of Agriculture. Brentwood. Same as preceding, adult on pine, May 5

Digitized by Google

Neilson, Miss N. Nyack. Same as preceding, June 18

Crosby, M. S. Rhinebeck. Through State Conservation Commission. Chermes abietis Linn., spruce gall aphid, galls on spruce, January 20

Harris, S. G. Tarrytown. Same as preceding, gall on Norway spruce, June 16

Laney, C. C. Rochester. Same as preceding, June 17

Gott, P. V. D. Goshen. Same as preceding, July 10

Miller, Mrs M. S. Boonville. Chermes strobilobius Kalt., woolly larch aphid, adults and eggs on larch, June 23

Nill, John. Star Lake. Chermes floccus Patch, galls on spruce, August 23

Frost & Bartlett Company. Stamford, Conn. Tetraneura ulmisacculi Patch, English elm pouch gall, galls on Ulmus campestris, June 5

Goodyear, Charles. Tarrytown. Pemphigus ulmifusus Walsh, slippery elm gall, gall on elm, June 24

Frost & Bartlett Company. Stamford, Conn. Same as preceding, August 23

Cox, Townsend, jr. Setauket. Pemphigus tessellata Fitch, alder blight, adults on soft maple, July 5

Harrer, Richard. New York City. Schizoneura lanigera Hausm., woolly apple aphis, aphis on apple, November 5

Patten, G. M. Poughkeepsie. Same as preceding, adults on apple, June 28

Seely, J. A. Ogdensburg. Same as preceding, young on apple, September 5

Rose, J. F. South Byron. Longistigma caryae Harr., hickory aphis, adults, June 4

Latham, Roy. Orient Point. Aphis maidis Fitch, corn leaf aphis on corn, November 2

Conkling, C. S. Gouverneur. ? Nectarophora solanifolii Ashm., potato plant louse on potato, September 27

State Conservation Commission. Lake Clear. Mindarus abietinus Koch., balsam aphid, work on balsam, June 9

Terry, S. S. Elizabethtown. Same as preceding, adults and work on balsam, June 21

Nill, John. Star Lake. Through State Conservation Commission. Same as preceding, June 14

Woolworth, C. C. Castleton. Gossyparia spuria Mod., elm bark louse, females on elm, June 13

Digitized by Google

Neilson, Miss N. Nyack. Same as preceding, adults on elm, June 18

Voorhis, A. M. Nyack. Phenacoccus acericola King, false maple scale on hard maple, October 18

Harrer, Richard. New York City. Same as preceding, November 5

Naramore, N. J. Ossining. Same as preceding, adults on bark, February 17

Patten, G. M. Poughkeepsie. Same as preceding, adults on maple, June 28

de Vyver, J. James. Bronxville. Same as preceding, females and young on sugar maple, September 26

Goodyear, Charles. Tarrytown. Pulvinaria acericola Walsh, adults on Cornus, June 13 and 24

Towson, C. R. New York City. Through State Conservation Commission. Pulvinaria vitis Linn., cottony maple scale, adults and eggs on soft maple, June 14

George, E. L. New York City. Same as preceding, June 18

Macey, Carleton. Hewlett. Same as preceding, July 14

Devers, M. J. Hoosick Falls. Same as preceding, adults on sugar maple, July 15

Livingston, J. H. Tivoli. Toumeyella liriodendri Gml., tulip tree scale, adults and young on tulip, February 1 and 5

Powell, Mrs T. W. Flushing. Same as preceding, August 15

Goodyear, Charles. Tarrytown. Same as preceding, adults and young on tulip, September 4

Latham, Roy. Orient Point. Eulecanium lintneri Ckll. & Benn., sassafras soft scale, adults and young on sassafras, July 21

Stene, A. E. Kingston, R. I. Eulecanium rugosum Sign., quince soft scale, adults on quince, June 3

Porter, E. H. New York City. Coccus hesperidum Linn., soft scale, adults on fern, May 29

Huested, P. L. Blauvelt. Physokermes piceae Schr., spruce bud scale on spruce, January 29

Dummett, Arthur. Mount Vernon. Same as preceding, eggs on Norway spruce, June 12

Hammond, Benjamin. Hudson Heights, N. J. Chionaspis euonymi Comst., Euonymus scale, adults on privet, probably Ligustrum bota, November 21

Haney, Theodore. Ravena. Chionaspis furfura Fitch, scurfy scale, eggs, April 17

Digitized by Google

Levison, J. J. Brooklyn. Chionaspis pinifoliae Fitch, the pine leaf scale, adult on Austrian and white pine, November 12

Terry, S. S. New York City. Same as preceding, adults on pine, July 12

Seaver, F. J. Diaspis echinocacti Bouché, Cactus scale, adults and young on cactus, from Porto Rico, September 30.

Barron, Leonard. Garden City. Diaspis carueli Targ., Juniper scale, adults on Arbor vitae, June 23

Cockerell, T. D. A. Los Banos, P. I. Drosicha lichenoides Ckll., fig scale on Ficus nata. Coll. C. F. Baker, 1912, cotypes, October 22

Niles, T. F. Through State Department of Agriculture. Aonidia lauri Bouché, Bay tree scale on Bay tree, October

State Department of Agriculture. Albany. Aspidiotus perniciosus Comst., San José scale, adults and young on rose, January 15

Albright, M. C. Coeymans. Same as preceding, young on elm, March 3

Bullard, T. E. Schuylerville. Same as preceding, adults and young on pear, July 8

Doyle, H. M. Oswego. Aspidiotus ostreaeformis Curt., European oyster scale, adult on apple, May 15

Stubing, F. J. Mount Vernon. Aspidiotus osborni Newell & Cockerell, oak scale, adults on white oak, October

Gordinier, H. W. Troy. Lepidosaphes ulmi Linn., oyster shell scale on poplar and maple, December 9

Strickland, L. F. Lockport. Neurocolpus nubilis Say, adult on sumac, July 12. Also Paracalocoris scrupeus Say, nymphs on grape, June 13 and July 12

Griffith, L. C. Lynbrook. Lygus pratensis Linn., tarnished plant bug, adults on crysanthemum, September 4

Plecoptera

Atwood, G. G. Albany. Pteronarcys ? biloba Newm., May 8

Blunt, Miss Eliza S. New Russia. Pteronarcys proteus Newm., giant stone fly, adult, June 6

Thysanoptera

Brooks, F. M. Athens. Euthrips pyri Dan., pear thrips, adults, April 25

Digitized by Google

Thysanura

Rodgers, E. H. Mount Kisco. Through State Department of Agriculture. Schoturus nivicola Fitch, snow flea, adults, December 26

Acarina

Hunter, Miss Louise. Cornwall. Eriophyes quadripes Shimer, gall on maple, May 12

Bethel, E. Denver, Col. Eriophyes abnormis Garm., gall on linden, September 30

Barron, Leonard. Garden City. Bryobia pratensis Garm., red spider, adults and eggs on Arbor vitae, June 23

ZOOLOGY

Donation

Mammals

Corbin, Austin. New York
Buffalo bull, Bison bison (Linnaeus)..... 1

Hartley, B. M. New Haven, Conn.
Jumping mouse, Zapus hudsonius (Zimmerman). 4

Taylor, H. L. Albany
Newfoundland caribou, Rangifer terrae-novae Bangs, head

Birds

Newland, D. H. Albany
Night heron, Nycticorax nycticorax naevius (Boddaert)..... 1

Birds' eggs

Philips, Mrs J. Kay. Menands
Brown pelican, Pelecanus occidentalis Linnaeus 1
Night heron, Nycticorax nycticorax naevius (Boddaert)..... 1
Spotted sandpiper, Actitis macularius (Linnaeus) 3
Ruffed grouse, Bonasa umbellus (Linnaeus)... 10
Mourning dove, Zenaidura macroura carolinensis (Linnaeus) 1
Cooper hawk, Accipiter cooperi (Bonaparte). 1
Flicker, Colaptes auratus luteus Bangs..... 3

Digitized by Google

Night hawk, Chordeiles virginianus (Gmelin). 1
Kingbird, Tyrannus tyrannus (Linnaeus)..... 1
Crested flycatcher, Myiarchus crinitus (Linnaeus)..... 2
Phoebe, Sayornis phoebe (Latham)..... 5
Crow, Corvus brachyrhynchos Brehm..... 11
Cowbird, Molothrus ater Boddaert..... 1
Red-winged blackbird, Agelaius phoeniceus (Linnaeus)..... 4
Meadow lark, Sturnella magna (Linnaeus).... 2
Orchard oriole, Icterus spurius (Linnaeus).... 2
Purple grackle, Quiscalus quiscula quiscula (Linnaeus)..... 6
Chipping sparrow, Spizella passerina (Bechstein)..... 4
Vesper sparrow, Pooecetes gramineus (Gmelin)..... 2
Savannah sparrow, Passerculus sandwichensis savanna (Wilson)..... 5
Song sparrow, Melospiza melodia (Wilson).. 4
Cliff swallow, Petrochelidon lunifrons (Say) 2
Cedar waxwing, Bombycilla cedrorum Vieillot 1
Catbird, Dumatella carolinensis (Linnaeus). 9
Veery, Hylocichla fuscescens (Stephen).... 2
Bluebird, Sialia sialis (Linnaeus)..... 4

Birds' nests and eggs

Van Name, W. G. Albany

Common tern, Sterna hirundo Linnaeus ..... 16 eggs
Roseate tern, Sterna dougalli Montagu ..... 5 "
Night heron, Nycticorax nycticorax naevius (Boddaert).....nest and 3 "
Night heron, Nycticorax nycticorax naevius (Boddaert)..... 5 "
Woodcock, Philohela minor (Gmelin) nest and 3 "
Spotted sandpiper, Actitis macularius (Linnaeus) ..... 3 "

Digitized by Google

Fish hawk, Pandion haliaetus carolinensis (Gmelin)..... 2 eggs
Chimney swift, Chaetura pelagica (Linnaeus).....nest and 2 "
Whippoorwill, Antrostomus vociferus (Wilson)..... 2 "
Kingbird, Tyrannus tyrannus (Linnaeus).....nest and 4 "
Phoebe, Sayornis phoebe (Latham)..nest and 5 "
Least flycatcher, Empidonax minimus (Baird).....nest and 4 eggs
Blue jay, Cyanocitta cristata (Linnaeus)..... nest
Bobolink, Dolichonyx oryzivorus (Linnaeus).....nest and 5 eggs
Cowbird, Molothrus ater Boddaert... 1 egg
Red-winged blackbird, Agelaius phoeniceus (Linnaeus).....nest and 4 eggs
Orchard oriole, Icterus spurius (Linnaeus).....nest and 4 "
Purple grackle, Quiscalus quiscula quiscula (Linnaeus)..... nest
Goldfinch, Astragalinus tristis (Linnaeus).....nest and 5 eggs
English sparrow, Passer domesticus (Linnaeus).....nest and 6 "
Vesper sparrow, Pooecetes gramineus (Gmelin).....nest and 4 "
Savannah sparrow, Passerculus sandwichensis savanna (Wilson)..... nest
Seaside sparrow, Passerherbulus maritimus (Wilson).....nest and 4 eggs
Chipping sparrow, Spizella passerina (Bechstein)..... 4 "
Field sparrow, Spizella pusilla (Wilson).....nest and 3 "
Song sparrow, Melospiza melodia (Wilson).....nest and 5 "
Towhee, Pipilo erythrophthalmus (Linnaeus).....nest and 2 "

Digitized by Google

Barn swallow, Hirundo erythrogastra Boddaert ..... nest
Cedar waxwing, Bombycilla cedrorum Vieillot ..... nest and 4 eggs
White-eyed vireo, Vireo griseus (Boddaert) ..... nest and 3 "
Yellow-breasted chat, Icteria virens (Linnaeus) ..... nest and 4 "
Yellow-breasted chat, Icteria virens (Linnaeus) ..... nest and 3 "
Redstart, Setophaga ruticilla (Linnaeus) ..... nest and 4 "
Catbird, Dumatella carolinensis (Linnaeus) ..... nest and 4 "
Brown thrasher, Toxostoma rufum (Linnaeus) ..... nest and 5 "
House wren, Troglodytes aedon Vieillot ..... 6 "
Wood thrush, Hylocichla mustelina (Gmelin) ..... nest and 4 "
Robin, Planesticus migratorius (Linnaeus) ..... nest
Bluebird, Sialia sialis (Linnaeus) ..... nest and 3 eggs

Fish

Gloeckner, William. Albany
Red horse mullet, Moxostoma aureolum (Le Sulur) 1

Invertebrates

Pearse, A. S. Madison, Wis.
Compound ascidian, Botryllus schlosseri (Pallas) 1
Van Alstyne, William T. New York
Collection of foreign shells and corals

Purchase

Mammals

Hartley, B. M. New Haven, Conn.
Rat, Epimys norvegicus (Erxleben) 2

Digitized by Google

Leach, B. J. Averill Park
Weasel, Mustela noveboracensis (Emmons).. 1
Ward's Natural Science Establishment. Rochester
Puma, Felis couguar Kerr..... 2
Fisher, Martes pennanti (Erxleben)..... 2

Birds

Barker, Fred. Parker's Prairie, Minn.
Caspian tern, Sterna caspia Pallas..... 1
American merganser, Mergus americanus Cassin. 1
Red-breasted merganser, Mergus serrator Linnaeus..... 1
Lesser snow goose, Chen hyperboreus (Pallas). 2
Canada goose, Branta canadensis canadensis (Linnaeus)..... 1
Bittern, Botaurus lentiginosus (Montagu)... 1
Black-crowned night heron, Nycticorax nycticorax naevius (Boddaert)..... 1
Wilson phalarope, Steganopus tricolor Vieillot. 1
Western sandpiper, Ereunetes mauri Cabanis.... 2
Long-billed curlew, Numenius americanus Bechstein..... 1
Black-breasted plover, Squatarola squatarola (Linnaeus)..... 2
Sharp-shinned hawk, Accipiter velox (Wilson). 1
Pigeon hawk, Falco columbarius Linnaeus..... 1
Pileated woodpecker, Phloeotomus pileatus abieticola (Bangs)..... 2
Hartley, B. M. New Haven, Conn.
Bluebird, Sialia sialis (Linnaeus)..... 1
Milton, B. New Haven, Conn.
Starling, Sturnus vulgaris Linnaeus..... 1
Vernon, M. L. Troy
Robin, Planesticus migratorius (Linnaeus) albino..... 1

Fishes

Purchased in Albany markets
Atlantic salmon, Salmo salar Linnaeus..... 1
Pike, Lucius lucius (Linnaeus)..... 1
Chub mackerel, Scomber colias Gmelin..... 1

Digitized by Google

Striped bass, Roccus lineatus (Bloch)..... 1
Sea bass, Centropristes striatus (Linnaeus).. 1
Sheepshead, Archosargus probatocephalus (Walbaum)..... 1
Sea trout, Cynoscion regalis (Bloch and Schneider..... 1
Summer flounder, Paralichthys dentatus (Linnaeus)..... 1

ETHNOLOGY

Purchase

Women's leggings, beaded (3 pairs)..... 6
Towesas rattle, made of box turtle..... 1
Turtle rattles, greatfeather dance..... 2
Husk faces used by Husk Face Company..... 2
False face, medicine mask..... 1
Small baskets 2
Husk basket 1
Berry basket 1
Beaded belt or sash..... 1
Snowshoes — short type 2
Baby board, Onondaga..... 1
Bark bowl 1
Wooden spoons 3
Worsted belt or sash..... 1
Paddles..... 4
Eagle wands (2 sets)..... 2
Eagle dance rattles, of gourds (set)..... 1
Eagle rattles, of horn (set)..... 1
Wooden spoon 1
Plum stone dice (set)..... 1
Peach stone dice (set)..... 1
Bone dice (set)..... 1
Calabash rattle 1
Gourd rattle 1
Drum and carved stick..... 1
Beaded sash 1
Old spoons of carved wood..... 4
False face 1
Husk basket 1
Husk jug or bottle..... 1

Digitized by Google

Brooches 2
Gambling bowl 1
Bark rattle 1
Old paddle 1
Pot hook of twisted wood 1
Woodchuck hide 1
False face 1
Turtle rattle 1
Pair earrings (natural silver) 1
Feast bowl 1
Silver rings 2

A. A. Schmidt. Albany

Indian bead-work bag 1

ARCHEOLOGY

Purchase

The R. D. Loveland Collection. Watertown.

Bone and horn arrow-heads 39
Stone axes 2
Bone awls 380
Banner stone 1
Copper bead 1
Small quantity charred corn ....
Celts 85
Small stone dart 1
Stone disks, diameter 4" to 5" 4
Bone fish hook 1
Phalanges 70
Gorgets 9
Gouges 7
Bone and horn harpoons 6
Hammer stones 25
Slate knives 11
Stone mortars 6
Mullers 30
Parts of antlers, worked 16
Human arm bone, worked 1
Small stone pigment bottle 1
Tattooing bone 1
Bone needles 8
Bone paddles or spatulas 1
Stone paddles or spatulas 1

Digitized by Google

Steatite plummet	1
Slate plummet	1
Stone pestles	3
Stone pendants	7
Stone balls	14
Part of turtle carapace, perforated	1
Worked bears' teeth	9
Clay pipes	139
Steatite pipes	4
Bone spear heads	2
Skull	1
Parts of clay pipes	7 qts.
Potsherds	about 350
Clay disks	41
Stone disks	18
Small stone ornaments	6
Beaver teeth, worked	6
Small stone cones	2
Small flat round stone, on one side effigy of human face	1
Bone shuttles	6
Stone pick	1
Stone hatchet, perforated	1
Antler spoon	1
Several lumps mineral paints	4
Small quantity charred wood	3
Clay pot	1
Stone paint grinder	1
Saucer-shaped dish from human skull	1
Stone and slate beads	298
Various small bone objects, worked	..
Stone net sinkers	19
Antler spoon	1
Shell beads	37
Unfinished stone and slate beads	38
Bone beads	75
Arrow points	147
Spear heads	16
Bone punches	3
Plum pits, perforated	3
Gun flints	4

Digitized by Google

The Raymond G. Dann Collection. Honeoye Falls

Clay pipes	36
Stone pipes	3
Flint spear heads	27
Gun flints	85
Copper arrow points	16
Red catlinite pipe	1
Stone axes	7
Celts	16
Stone maul	1
Flint scrapers	12
Gorgets	3
Shell beads	9
Flint drills	3
Flint knives	13
Chert arrow points	247
Bone awls	6
Bone punch	1
Bone harpoon	1
Bone pins	4
Bone shuttles	2
Sinew stone	1
Stone war clubs	2
Banner stones	2
Stone pestles	3
Stone gouges	4
Wolf tusk necklace, 91 teeth	91
Red stone bead necklace	223
Metal spoon, round bowl, figure of human on end of handle	1
Shell disk	1
Shell object, flat discoidal base, 1¼" shaft from one side	1
Bear tusk necklace, 56 teeth	56
Carved shell necklace, 78 pieces	78
Bracelet of copper wire	1
Necklace of carved shell, 91 pieces crescent shape	91
Carved shell necklace, 18 pieces	18
Shell necklace, 30 pieces	30
Tortoise shell rattles	2
Cylindrical shell ornament	1
Shell ornament, representation of turtle	1
Shell ornament, representation of duck	1

Digitized by Google

Shell ornament, representation of owl	2
Small human figure, horn	1
Small cup-shaped stone	1
Small stone saucer-shaped object	1
Iron scissors, rusted	1
Carved shell necklace, 31 pieces	31
String of 38 discoidal shell ornaments	38
Carved shell, representation of duck	1
Shell necklace, crescent shape pieces	61
Discoidal shell object	1
Long shell beads	7
Perforated tortoise carapace	1
String of shell beads	16
Four strings glass beads	..
String red stone beads	22
Loose wampum and other beads	..
One-half pint wampum shells	..
White glazed pottery vase, European, top broken	1
Copper finger rings	9
String wampum beads and wolf teeth	58
Flint lock from gun	1
Remnant of flint lock	1
Pottery ornament, head of duck	1
Iron tube 5¼″ long	1
Lead ladle	1
Small piece beaver skin, 2″ x 2½″	1
Small round bells, copper	2
Small copper bells	4
Iron wire bracelet, small coil copper wire attached	1
Oblong shell beads, white	7
Small maskette, white shell	1
Trade pipe, bowl broken and large part of stem missing	1
Fragments of worked shell, white, four pieces	4
Shell ornaments and fragmentary pieces	18
Mother of pearl ornament	1
Bone, crescent shape pieces	6
Copper jingles	2
Copper chain, length 37½″	1
Small piece graphite	1
Small fragment leather, copper bead insertion	1
Small figures of animals, bone	4

Digitized by Google

Lead bullets 175
Copper thimble 1
Copper kettles 4
Earthen vessels 7
Brass kettles 3
Horn and bone combs 17
Brass spoon 1
Iron knife 1
Iron tomahawks 2
Lead spoon 1
Wooden spoons 5
Bone spoons 3
Shell ornaments 5
Horn knife handles 8
Iron implements, wedge shape 3
Stone implements 10
Shell pendant 1
Bear tusks 2
String wampum and other beads, multi-colored, 60 yards.

The Fred H. Crofoot Collection. Sonyea

Copper axe 1
Celts 810
Stone implements 19
Stone axes 212
Stone war clubs, heads 242
Hammer stones 254
Brass kettles 2
Cylindrical stone pestles 174
Bell pestles 8
Iron axes 11
Mullers 199
Copper bullets 38
Stone balls, picked 59
Flint drills 138
Bone awls 11
Large clay council pipe 1
Stone mauls 29
Sinew stones 47
Stone net sinkers 46
Stone gouges 17
Flattened pitted stones, several pits on one side 7

Digitized by Google

Stone mortars	4
Flint arrow and spear heads	5832
Flint scrapers	642
Brass arrow heads	2
Small earthen pot	1
Flint knives	676
Bear teeth	6
Gun flints	53
Small stone mortar and ball	1
Bone whistle	1
Silver brooches	4
Silver totem	1
Copper pipes	2
Steatite platform pipe	1
Copper spear head	1
Gorgets	20
Parts of gorgets	27
Banner stone	1
Parts of banner stones	11
Copper beads	4
Iron knives	17
Iron scrapers, spoon shaped	2
Turtle back stone	1
Iroquois clay pipe	1
Steatite paint cup	1
Lead seal	1
Flint semi lunar knives	3
Stone tube	1
Shell gorget	1
Bone scrapers	2
Games, stones	2

The C. A. Holmes Collection. New Berlin

Iron axes	2
Flint arrow points, drills, spear heads, scrapers	about 550
Flint knives	6
Gun flint	1
Gorgets	6
Stone pestles	10
Crude chipped flint fragments	33
Stone net sinkers	10
Celts	11

Digitized by Google

Hammer stones	8
Stone axes	2
Stone war clubs	2
Sinew stone	1
Small mortar	1
Muller	1
Bell pestle	1
Plaster cast Mound Builders pipe	1
Plaster cast large spear head	1
Stone gouges	3
Banner stones	2

The W. E. Bryan Collection. Elmira

Small oblong stone, effigy of human face on one side	1
Small bottle, charred cover	1
Potsherds	138
Stone net sinkers	59
Crude chipped stone implements	7
Celts	66
Stone mortars	2
Bone awl	1
Parts of gorgets	6
Flint knives	25
Stone pestles	14
Lapstone	1
Stone gouges	2
Pieces of steatite, parts of pots	54
Flint spear heads	4
Flint scrapers	13
Flint drills	38
Part of banner stone	1
Arrow points	604
Gun flints	4
Stone balls	2
Mullers	4
Hammer stones	33
Stone war clubs	12
Iron axe	1

The R. E. Van Valkenburg Collection. Mount Upton

Shell disks, center perforation	5
Flint drills	5
Flint scraper	1

Digitized by Google

Flint knives 3
Flint spear head 1
Smoothing or lapstone 1
Stone pestles 6
Flint harpoon 1
Mullers 2
Stone net sinkers 27
Worked stones 29
Sinew stones 2
Celts 2
Hammer stones 43
Flint arrow points 203

The Charles P. Oatman Collection. Liverpool (Collected in Jefferson county)

Clay pipes 93
Steatite pipes 4
Diminutive clay cup, diameter about 1¼" 1
Small clay effigy of human head 1
Small clay effigy of human head, part missing 1
Small bone from mouth of sturgeon 1
Small oblong flat bone fragment, worked, two perforations 1
Part of lip of platform pipe, red catlinite 1
Miniature bone paddle, 4½" long 1
Clay pipe fragments ..... about 150
Bone awls 251
Bone and horn arrow points 39
Worked phalanges 57
Bone beads 53
Celts 68
Bone bodkins 8
Bone harpoons 7
Shell beads 5
Stone mortars 2
Small pieces perforated skull 2
Hammer stones 7
Bone knives 3
Mullers 15
Copper beads 4
Stone beads 6
Small quantity charred wood ....
Pieces of pigment 4

Digitized by Google

The Alva S. Reed Collection. Livonia

Miniature bone effigy, human foot	1
Shell ornaments	10
Shell beads	61
Shell implements	1
Copper bead	1
Stone beads	8
Small pieces bones, notched	2
Clay bead	1
Shell gorget	1
Bone harpoons	5
Bone needles	13
Bone whistle	1
Bone pitching tools	13
Bone ornament	1
Bone fish hooks	5
Brass arrow point	1
Worked animal teeth	70
Bone implements	16
Worked antlers	2
Bone beaming tools	6
Bone awls	52
Bone arrow point	1
Bone shuttle	1
Bone beads	71
Bone pendants	2
Flint arrow points	about 300

McCombs, Mrs F. A., Rushville

Broken adult female skull	1
Broken abnormal juvenile skull	1
Stone tubes	3
Gorget	1
Small copper celt	1
Antler punch	1
Ivory blade, broken	1
Amulets	2
Strings shell beads	2

The Vander Veer-Auringer Collection, from headwaters of the Hudson, Warren county

Glass and bone string beads	75
Copper thimble	1

Digitized by Google

Small crescent-shaped bone ornament, two perforations	1
Brass arrow point	1
Small lead bird effigy	1
Stone spatula	1
Bone jingler	1
Bar amulets	3
Large bell mortar, stone	1
Double stone mortar	1
Mullers	7
Sinew stones	2
Stone pestles	8
Stone grinder	1
Stone war clubs	4
Stone balls	5
Part of banner stone	1
Flint knives	41
Flint gouge	1
Celts	5
Flint pick	1
Hammer stones	14
Stone spades or hoes	4
Stone axes	14
Stone paint grinder	1
Stone net sinkers	10
Crude chipped stone fragments	50
Iron axe	1
Iron ball	1
Steel trade arrow or lance	1
Gun flints	2
Eskimo knives	16
Worked steatite fragments	6
Bone punch	1
Flint drills	10
Bone implement	1
Flint scrapers	24
Flint spear heads	41
Flint arrow points	168
Bone awls	5
Pigment lumps, small	3
Brass bracelets	2

Digitized by Google

Collection

The D. D. Luther Collection. Naples

Small red stone effigy of human face	1
Smoothing or lapstones	13
Stone gouge	1
Stone pestles	10
Stone sinkers	50
Stone balls	3
Muller	1
Stone mortar	1
Celts	6
Stone war clubs	2
Hammer stones	226
Stones, worked	35
Potsherds	27
Flint arrow points	60
Flint scraper	1
Gun flints	2
Clay pipe	1

Digitized by Google

Digitized by Google

APPENDIX

THE ORIGIN OF MAN

(Adapted from a paper by Dr E. Rivet, of the Museum d'histoire naturelle, Paris)[1]

The progress of recent investigations into the prehistory of the human race has plainly shown that the common expression which has come into use as the summation of the evolutionist theory of the origin of man, "man is descended from the ape," is not only unfortunate but untrue. When this expression became current it attracted attention and controversy by its implied defiance of traditional doctrines, and this very fact has given it a certain popularity, made it the target of polemic discussions and has indeed cast ridicule upon the fundamental scientific principle of evolution. The responsibility for the diffusion of this formula rests in part upon scientific men themselves. The time is not far past when such men as Haeckel and Mortillet imagined and even portrayed the precursor of man as a strange compromise between man and the anthropoid, and to these imaginary creatures they gave some such significant names as Pithecanthropus or Anthropopithecus, and Schaafhausen made out the man of Neanderthal to be a sort of man-ape.

The views of Haeckel and contemporary writers were not, however, without excuse. After the first discoveries relative to fossil man had been made, they were prone to believe that the problem of our origin was of quite simple solution; but this is not at the present time so regarded. The new data acquired in the course of late years show that the problem is much more complex than it has appeared to be. It is this fact that I wish specially to lay emphasis upon in bringing together here what we now know with scientific certainty regarding this matter and the conclusions which it is legitimate to draw therefrom.

It is well known that the history of the earth has been divided by geologists into four great periods, Primary, Secondary, Tertiary and Quaternary. The first era is characterized by a fauna composed of invertebrate animals and of the lower vertebrates; the Secondary era is the era of reptiles; the Tertiary and Quaternary eras those of the mammals. The Tertiary era has been divided

[1] Printed in *Biologica*, March 15, 1914.

Digitized by Google

GEOLOGICAL DIVISIONS			CLIMATE	CHARACTERISTIC ANIMALS	INDUSTRY	HUMAN OR ANTHROPOMORPHIC TYPES
Quaternary	Recent or Holocene		Like that of the present	Living species and domestic animals	Metals. Neolithic Azilian Magdalenian Solutrian Aurignacian	*Homo sapiens*
Quaternary	Early or Pleistocene	Upper....	Postglacial period Climate cold and dry	Fauna of the Steppes Abundance of Reindeer	Solutrian Aurignacian	*Homo sapiens*..... Cro-Magnon-type; Chancelade-type
Quaternary	Early or Pleistocene	Middle...	Climate cold and moist	Mammoth Hairy rhinoceros Reindeer	Mousterian	*Homo sapiens*..... Grimaldi-type
Quaternary	Early or Pleistocene	Middle...	Glacial advance	Mammoth Hairy rhinoceros Reindeer	Mousterian	*Homo neanderthalensis*.... Gibraltar. 1848; Neanderthal. 1856; La Naulette. 1866; Spy. 1886; Malarnaud. 1889; Krapina. 1899; La Chapelle-aux-Saints. 1908; La Moustier. 1909; La Ferrassie. 1909–10; La Quina. 1911
Quaternary	Early or Pleistocene	Middle...	Climate cold and moist	Mammoth Hairy rhinoceros Reindeer	Acheulian	*Homo neanderthalensis*.... Gibraltar. 1848; Neanderthal. 1856; La Naulette. 1866; Spy. 1886; Malarnaud. 1889; Krapina. 1899; La Chapelle-aux-Saints. 1908; La Moustier. 1909; La Ferrassie. 1909–10; La Quina. 1911
Quaternary	Early or Pleistocene	Lower....	Interglacial period Climate mild	Hippopotamus *Elephas antiquus*	Acheulian	*Homo neanderthalensis*.... Gibraltar. 1848; Neanderthal. 1856; La Naulette. 1866; Spy. 1886; Malarnaud. 1889; Krapina. 1899; La Chapelle-aux-Saints. 1908; La Moustier. 1909; La Ferrassie. 1909–10; La Quina. 1911
Quaternary	Early or Pleistocene	Lower....	Glacial advance Climate cold and moist	Hippopotamus *Elephas antiquus*	Chellian	*Homo heidelbergensis* *Eoanthropus dawsoni*
Tertiary	Upper Pliocene		Interglacial period Climate warm Glacial extension Climate cold and moist	*Elephas meridionalis*	Eolithic (?)	*Pithecanthropus erectus*

Digitized by Google

also into four periods, Eocene, Oligocene, Miocene and Pliocene. In our present theme only this last and most recent period, the Pliocene, interests us. At this epoch the climate of Europe was warm and its fauna included such a characteristic animal as the northern elephant. The Quaternary, also, has been divided into the present Quaternary or Holocene, characterized by a climate and a fauna very like those of the present, and into an ancient Quaternary or Pleistocene. The latter comprises three periods: Lower Pleistocene, with a mild climate, during which the hippopotamus and the Elephas antiquus abounded in our region; the Middle Pleistocene, with a cold and humid climate, the fauna of which included the mammoth, the hairy rhinoceros and the reindeer; finally, the Later or Upper Pleistocene, with a cold, dry climate, often called the *Reindeer age,* on account of the extreme abundance of this animal. Toward the end of this epoch the fauna was very like that of the steppes.

Thus arranged, what are the discoveries relating to man and his predecessors which have been made in the different beds corresponding to the divisions just enumerated? It is believed that we have found traces of the existence of man, or at least of a being resembling man, in the Tertiary epoch, shown by the discovery of incised bones and, in many places, of stones which bear traces of use, the so-called *eoliths.* These eoliths have given rise to lively discussions, but today, thanks to the work of MM. Boule and Breuil, it is proved that flints may acquire the aspect of stones intentionally retouched merely by the effect of contusion in torrential waters or under the pressure of the rocks themselves, and it is admitted now almost unanimously that even if a human being living in the Tertiary epoch actually made use of stones, it would be impossible, in the present state of our knowledge, to distinguish them from those which have been bruised and broken by the action of natural causes. It has, moreover, not been proved that incisions found on certain Tertiary bones are the work of man. Of the being who might have modeled these eoliths or made these incisions, there has not, thus far, been found in our country the slightest vestige, and the expression of Nadaillac in 1885 is today the exact truth: " Man might have been able to live during Tertiary times. Nothing in the climate or geologic conditions, nothing in the fauna or in the flora is opposed *a priori* to his existence then, but up to the present time there is no known fact, no discovery, no proof which can really permit us to affirm this with any degree of certitude."

Digitized by Google

I have not as yet taken account of the famous discovery made in Java in 1891–92 by Dr Eugene Dubois of certain fragmentary bones, a calvarium, a femur and a molar of a being which has received the name of Pithecanthropus erectus. The age of these bones has been discussed at length and is not yet definitely determined, but it does not seem to carry us back to an epoch earlier than the period of transition from the Pliocene to the Pleistocene. They are nevertheless the most ancient anthropomorphic remains which we possess and I shall have to refer later to their interpretation.

Up until 1907 we knew the human being who lived in Europe during the Lower Pleistocene only by his industry, but, in the course of the last three years, two sensational discoveries have brought us the first definite proof of the physical characteristics of this being. There was, first of all, the discovery in 1907 of a lower jaw in the sands of Mauer, near Heidelberg; then in 1912 the discovery of a portion of the cranium and the lower jaw in the gravels of Piltdown, in Sussex.

Much more numerous and more important are the documents which we possess relating to the man of the Middle Pleistocene. Following the chronological order and retaining only the undebated and undebatable examples, we may cite: the cranium of Gibraltar, 1848; the calvarium of Neanderthal, 1856; the jaw of La Naulette, 1866; the cranium and bones of Spy, 1886; the jaw of Malarnaud, 1899; the multiple debris of Krapina, 1899; the skeleton of La Chapelle-aux-Saints, 1908; the skeleton of Moustier, 1909; the two skeletons of La Ferrassie, 1909–10; and, finally, the skeleton of La Quina, 1911.

From the epoch intermediate between the Middle Pleistocene and the Later Pleistocene there have been reported two skeletons discovered in the lower beds of one of the caves of Grimaldi, near Menton, and described by M. Verneau. Finally, the Later or Upper Pleistocene has furnished so many evidences of fossil man that a list of them would be too long to give here.

This is a summary of the paleontologic human documents which we possess today. Let us now see the data which the study of these precious remains affords for the determination of the morphology of our ancestors.

A rapid examination shows, first of all, and this is a capital point, that man of the Later Pleistocene had already the characters of living man, or, in other words, to employ the language of the

Digitized by Google

systematists, that at that epoch he entered into the group of Homo sapiens. True enough, even then he afforded a large variety of types analogous to if not identical with those which we find today: the Grimaldi-type with negroid characters very strongly expressed; the Chancelade-type which approaches the type of the Eskimo; and, finally, the Cro-Magnon-type, much more widely diffused and whose descendants Professor Verneau has found among the almost contemporary Guanchos of the Canary islands. It is fair then to say that living humanity was already in possession of its essential traits and even of its principal varieties in the Later Pleistocene. Because of this fact our study finds itself restricted to human fossils of the Middle and Early Pleistocene. The Middle Pleistocene man, which has generally been designated

Jaw of the Heidelberg man (Homo heidelbergensis)

by the name of Homo neanderthalensis, is actually very well known morphologically, thanks to the beautiful work of M. Boule.

We know much less of the man or the anthropoid creatures which preceded Homo neanderthalensis; in fact, we have as documents here only insufficient and scattered bone fragments. The lower jaw, the only relic of the creature to which the name of Homo heidelbergensis has been given, is remarkable for the association which it presents of pithecoid and human characters. It is striking throughout by its massive appearance, by the large size of its ascending branches and by the complete absence of a chin. The mandibular angle is truncated, the semilunar groove but slightly marked, the coronoid apophysis obtuse and with rounded edges, the articular surface of the condyle much

Digitized by Google

Superior surface of the crania of (1) the chimpanzee, (2) the fossil man of La Chapelle-aux-Saints, (3) a Frenchman.

Side views corresponding with the foregoing

Digitized by Google

extended. Finally, if the bone is placed on a horizontal plane it will be seen that there is a large open space under the median symphysis. All these characters give this jaw more the aspect of an anthropoid than of a human jaw, and it is certain that if it had been deprived of its alveolar border it would have been greatly to the embarrassment of paleontologists; but the teeth are distinctly human and the canines no more prominent than the adjoining teeth.

Again, we find the association of such pithecoid and human characters, in a fashion perhaps still more pronounced, in Eoanthropus dawsoni; that is to say, in the being whose remains have been discovered at Piltdown. Morphologically, this jaw is the jaw of a chimpanzee, and the recent discovery of the canine tooth notably more developed than the human canine accentuates this resemblance; but the cranium, as far as one is able to judge from the deteriorated condition in which it was found and after somewhat varying reconstructions which have been made of it, is much more allied to the cranium of the existing man than to that of Homo neanderthalensis.

With Pithecanthropus erectus the phenomena are inverted. Here, in fact, are a femur and a molar which are clearly human, while the cranium is very far removed from the cranium of H. sapiens. Its aspect recalls that of the cranium of the Middle Pleistocene man, although it exaggerates those characters. The orbital ridge is sharper and consequently more pithecoid, the frontal more depressed, the vault more depressed, the occipital region more prominent and, finally, the cerebral capacity, which in Homo neanderthalensis is 1400 cubic centimeters, in Pithecanthropus certainly did not exceed 1000 cubic centimeters. In Pithecanthropus we have reached the most ancient known representative of human beings or anthropomorphs which excavations of the last fifty years have brought us. It is now necessary for us to inquire how it is possible, in the present state of science, to interpret these documents and with their help to solve the problem of the origin of man.

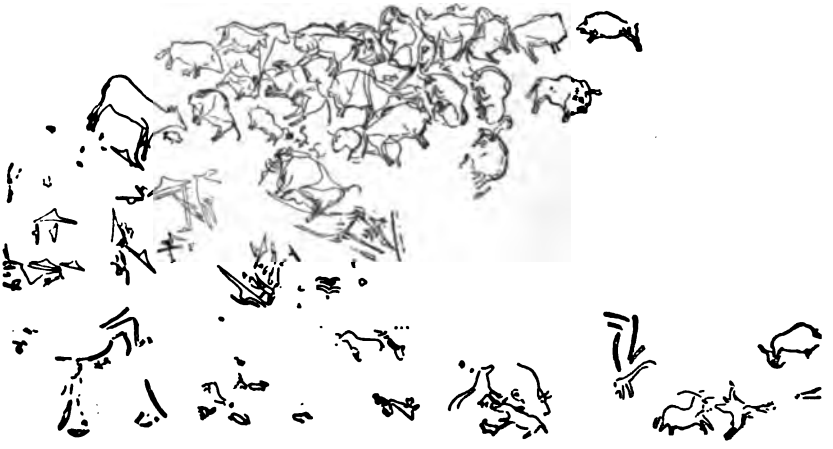
Homo neanderthalensis constitutes naturally the keystone of the whole edifice which we attempt to construct with the elements I have briefly described, because chronologically it is the first positively human being different from living man which has reached us, and especially because it is best known to us.

The morphological study of this fossil brings out two capital facts: one, the extraordinary homogeneity of the ethnic type which

Digitized by Google

it represents, the other, the profound difference which exists between it and the human beings which immediately followed it.

Wherever discoveries have been made of remains of the Middle Pleistocene man, whether in Croatia, in Prussia, in France, or in the south of Spain, everywhere the type shows a remarkable uniformity which contrasts in a singular way with the ethnic polymorphism of later epochs. However long may have been the period of geological times in which the race lived, all discoveries of Homo neanderthalensis show only a slight evolution, manifesting itself by noticeable skeletal variations. Everywhere and always it remains like itself.



Miniature diagram of frescoes from the ceiling of Altamira cavern, showing how the figures are thrown together with little regard for composition or position.

After Cartailhac and Breuil *Courtesy American Museum of Natural History*

The absence of the morphological link between Homo neanderthalensis and Homo sapiens is a fact no less remarkable. It is, moreover, like a corollary of the first. When one compares the Middle Pleistocene man with the Later Pleistocene man (of Grimaldi, Chancelade or Cro-Magnon) or even with the lowest representatives of living humanity, it is evident that back of these superficial similarities relating to certain isolated particulars one can not bring forward sufficient evidence of conformity of characters to establish any admissible morphological affinity between Homo neanderthalensis and Homo sapiens.

Digitized by Google

It is a remarkable fact that this morphologic hiatus coincides with a culture hiatus, as has been strongly insisted on by the Abbé Breuil. Homo neanderthalensis had an extremely rudimentary industry in which nothing of the slighest esthetic tendency has revealed itself. On the contrary, the man of the Upper Pleistocene possessed very varied culture; with equal skill he worked in stone, reindeer antlers and bone, and finally and especially he appears to have been a marvelous artist whose multiple productions in sculpture, engravings, designs and paintings are often veritable chefs d'oeuvre.

Far from finding a satisfactory term of passage between the cranium of La Chapelle-aux-Saints and the crania of Grimaldi or

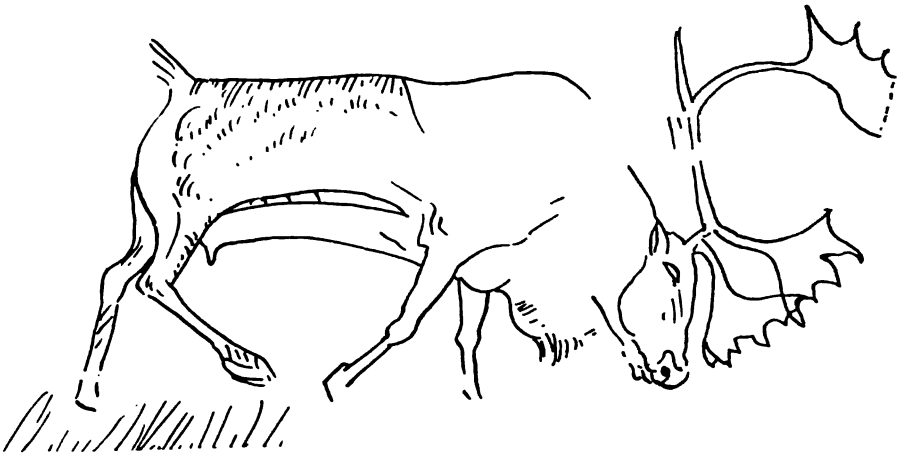
Magdalenian painting from the cave of Altamira

Cro-Magnon, one finds no transition between the fragmentary Mousterian civilization and the admirable cultures of the Aurignacian, Solutrian and Magdalenian man. In order to concede any relation between these types or between these industries, it is necessary to suppose that at the end of the Middle Pleistocene a mutation was produced which abruptly transformed Homo neanderthalensis into Homo sapiens. Need I say that this hypothesis can no more be seriously entertained than the creationist hypothesis? In reality this morphologic and industrial hiatus simply proves that living man, like the man of the Upper Pleistocene of which he is the issue, was not the direct descendant of Homo neanderthalensis; that the latter represents a

Digitized by Google

divergent line of the genus Homo which became extinct before the present era, while Homo sapiens represents the development of another line which paleontological discoveries made up to the present time do not permit us to follow into the Middle Quaternary.

The recent discoveries at Piltdown and Heidelberg have a definite bearing on this hypothesis; although greatly different in many details of structure from the Homo neanderthalensis, the Heidelberg jaw nevertheless does not present any essential differences from the latter. It is without doubt more robust, shows more pronounced primitive characters, but M. Boule has shown that it might well be adapted to the cranium of La Chapelle-aux-Saints



A reindeer grazing, from the cavern of Kesslerloch near Thayugen, Switzerland, engraved on a shaft-straightener. A Magdalenian masterpiece.
After Sollas *Courtesy American Museum of Natural History*

without sensibly changing its general aspect, and if we consider that it carries us back to an epoch anterior to that in which the man of the Middle Pleistocene lived, we can see in it one of the primitive stages of the latter; or, otherwise speaking, we may suppose that Homo heidelbergensis represents in the Lower Pleistocene the ancestral form of Homo neanderthalensis.

The discovery at Piltdown is of more delicate interpretation and this is because of the fragmentary condition of the remains. The jaw is distinctly pithecoid, although the cranium appears much more related to that of recent man than to that of the Homo neanderthalensis. At first sight one can not fail to be surprised

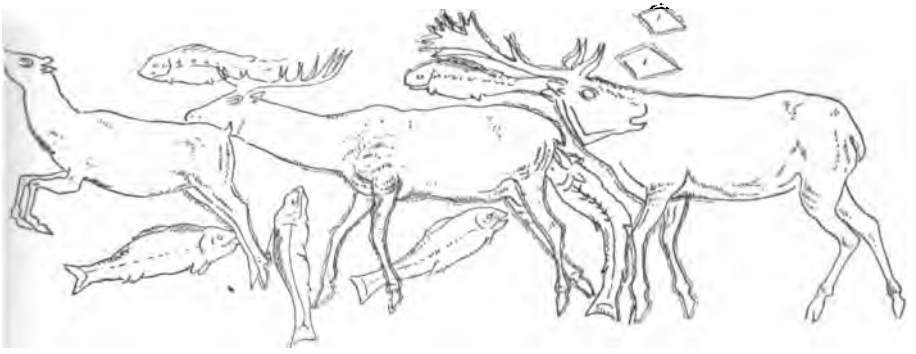
Digitized by Google

Group of two Bisons, modeled in clay. From the cavern of Tuc d'Audoubert

Digitized by Google

Digitized by Google

at the association in the same individual of simian and human characters so emphatically developed, and when one considers that the first are localized in the mandible, the second in the cranium, it is reasonable to question whether the sands of Piltdown may not have furnished the bones of two different individuals, an anthropoid and a man. The improbability of this hypothesis, which has been suggested by savants of distinction, of course, *a priori*, can not be escaped. It is necessary, nevertheless, to remark that as yet no anthropoid has been discovered in the European Lower Pleistocene. If the duality of the Piltdown discovery is rejected, Eoanthropus dawsoni would be one of the surprising synthetic forms of which paleontology has revealed to us the existence in other fossil groups. In any case, if the reconstructions submitted



Engraving on horn, partly restored, from the cavern of Lorthet, regarded as one of the finest examples of Magdalenian art.
After Ray Lankester *Courtesy American Museum of Natural History*

by the English anthropologists are exact, this being can not in any wise, on the basis of its cranial characters, take its place in the phylum of Homo neanderthalensis, and it will be logical to suppose that it represents the ancestral form from which Homo sapiens has been derived by an evolution whose stages have escaped us in the course of the Middle Pleistocene. We should have thus found at the opening of Quaternary time, the duality of types which we have vainly searched for in the Middle Quaternary. Their discovery would be here of great interest. Nevertheless, it is necessary to await other evidence before drawing any conclusions regarding this.

The absence of all remains of Homo sapiens in the Middle Quaternary can be explained in a quite simple manner. A certain

Digitized by Google

number of paleontologists, among them notably M. Boule, are disposed to believe that we have not yet found our direct ancestor in the Middle Pleistocene, it is really because that creature did not exist in our regions at that time, and that he invaded them only during the last period of the early Quaternary, bringing with him his magnificent civilization. In this hypothesis the country of origin of this creature would be probably Asia, from which so many later invasions departed toward Europe.

The discovery of the remains of Pithecanthropus in Java long ago turned the attention of paleontologists in this direction toward an epoch in which the problem of the origin of man does not present itself with its present complexity. It was in Asia, it is supposed, that the development took place of the hypothetical being, the probable parent of Pithecanthropus, from which was descended Homo neanderthalensis, and which later in its turn gave origin to Homo sapiens. We have seen that the second part of this hypothesis is not favored at the present time, but it is recognized that the first part can still be defended with serious arguments. It is certain, in fact, that, *morphologically,* the cranium of Pithecanthropus affords an excellent passage term between the great apes and the man of the Middle Quaternary. At the same time nothing proves that, *phylogenetically,* it represents the transition between the Pliocene ancestors of those apes and itself, for one must bear in mind that it is with the anthropoids of those ancient epochs and not with the living anthropoids that the affinity must be searched for and demonstrated, and in the absence of documents we have no evidence bearing on this point.

Another conception consists in seeing in Pithecanthropus a Gibbon of great size. This rests in part upon morphologic comparisons and in part also, as M. Boule has remarked, on the frequent occurrence in the geological epoch to which the Java fossil belongs of gigantic animals whose living representatives are of greatly reduced dimensions. Pithecanthropus would stand to the Gibbons as Megatherium and the Glyptodon of America do to the Armadillos and the Sloths, the Diprotodon of Australia to the Marsupials, the Trogontherium of Europe to the Beavers, the Megaladapis of Madagascar to the Lemurs. Consequently Pithecanthropus could not properly be attached to the human line but is related to a different line, that of the anthropoids; and just as Homo neanderthalensis represents a divergent branch and terminal of the genus Homo, Pithecanthropus erectus would be a

Digitized by Google

divergent branch and terminal from the trunk of which have issued the great anthropomorphic apes.

In resumé, the incontestable advances of paleontology have everywhere served to clear up these later discoveries. They have given precision to the problem of the origin of man, although without bringing any definite and final solution. Recent discoveries have established the fact that there developed in Europe during the Lower Quaternary, a human type absolutely different from the modern type, having certain pithecoid characters more marked than the lowest contemporaneous races, but nevertheless unquestionably meriting the name of man. The interpretation of these discoveries leads us to suppose that at the same time with this inferior creature there probably existed another human type (of which the Piltdown skull is perhaps the first evidence as yet known), the evolution of which comes out in the human races of the Later Quaternary, and consequently in the living races. But nowhere in *Europe*, so far as we have gone back into the past, have we yet found an anthropoid form from which might have issued the various types of the genus Homo.

Man has then behind him a long series of ancestors of human form of which we have as yet recognized only a few.

All that we know today of the history of the fossil apes proves that, as in the human branch, the simian branch plunges back into the depths of the past, with no present fact known that permits us to fix upon the epoch at which these two branches united into one common trunk.

The most ancient Primates known appeared in the Lower Eocene, near the opening of the Tertiary era, in North America, as creatures of a generalized type, on account of which it is very difficult to distinguish them from certain contemporary animals which it is necessary to place at the origin of other orders, such, for example, as the Insectivores. The most differentiated among them may be related to the living Lemurs. These Primates living primitively on the North American continent or in a boreal American-European continent, probably emigrated in part toward South America where they gave origin to the Platyrhine apes, partly toward Europe where they are known to have appeared during the Middle Eocene and to have multiplied in the Upper Eocene and Lower Oligocene, afterward passing into Asia, then into Africa, and finally to Madagascar where they have given birth to the various species of Lemurs in this island.

Digitized by Google

The discoveries made at Fayoum in Egypt in 1910 and studied by Schlosser, show that in the course of the Oligocene these lower types of Primates gave rise to forms which have been regarded in part as the ancestors of the Catarhine apes and, in part, of the anthropoids. In fact, it is at about this epoch that the differentiation took place, for on leaving the Miocene all the remains of apes discovered present very close affinities with the living species. I may cite for the Miocene epoch the Pliopithecus antiquus, a close ally of the gibbons, the Mesopithecus pentelici, intermediate between the macaque and the Semnopithecus, and for the Plio-Miocene epoch the Cynocephalus subhimalayanus, which is a true baboon; the Palaeopithecus sivalensis, which presents the characters both of the orang and of the chimpanzee; the Sivapithecus indicus which has certain affinities with the gorilla. In the Pliocene, and much more emphatically during the Pleistocene, the identity of the fossil with the living species must be regarded as probable.

It is then evident that the human phylum and the simian phylum have developed in parallel lines, each dividing and subdividing ever since time of extremely ancient date, and without paradox one may say that if Homo neanderthalensis had had, like ourselves, a curiosity in regard to his origin, the problem he set before himself would be almost in the same terms as that which presents itself to us. That at a geological epoch still more remote, so far back that our present knowledge will not permit us to fix it with precision, these two phyla were but one, losing themselves then in a common ancestor, we can not doubt. That paleontology will bring us some day documents which will permit us to establish the complete chain of this double genealogy, human and simian, the capital discoveries of the last years permit us to hope. One must give credit to the science which has already resolved so many secrets of dead nature, and we may affirm now that when this work is complete, man and the ape will appear as the ultimate forms of lines which have evolved independently for so long a time that there has never been any veritable parent of both.

Karl Vogt said he would rather be a perfected ape than a fallen angel. We do not have to choose between these alternatives. We know that man is neither one nor the other.

Digitized by Google

INDEX

Accessions to collections, 111–41
Albany county, place names, 44–50
Ambrosia beetle, pitted, 87
Apple tent caterpillars, 84
Archeologist, report, 93–102
Archeology, exhibit, 33; accessions to collections, 131–41; bulletin, 105
Areal geology, 58–67
Attica and Depew quadrangles, 58, 106

Banded grape bug, 85
Bark beetles, 87
Birds nests and eggs, added to collection, 126–28
Birds of New York, 92, 106
Blue Mountain quadrangle, 59–61
Botanist, report, 80–83, 106
Brier Hill quadrangle, 61–62
Brown-tail moth, 85
Bulletins, 104–6; in press, 106
Burnham, S. H., resignation, 80

Canton quadrangle, 62–67
Cases, new, 5–28
Champlain valley postglacial waters, 67
Chestnut borer, two-lined, 87
Clarke, John M. and Ruedemann, Rudolf, Eurypterida of New York, 104
Code of Handsome Lake, the Seneca prophet, 105
Codling moth, 84
Coins, medals and paper money, report on collection, 107–8
Connecticut river valley postglacial waters, 67
"Cryptozoon ledge," Greenfield, Saratoga county, 39
Cushing, H. P., work on Brier Hill and Ogdensburg quadrangles, 61–62

—— & Ruedemann, Rudolf, Saratoga and Schuylerville quadrangles, 59

Economic geology, accessions to collections, 111–13
Elm leaf beetle, 86
Entomologist, reports, 84–90, 105, 106
Entomology, accessions to collections, 116–25; bulletin, 105
Ethnology, report on, 97–99; accessions to collections, 130–31
European wolf, 86
Eurypterida of New York, 104

Fairchild, H. L., observations upon changes in postglacial waters, 67
False maple scale, 86
Finger Lakes region, relief map, 34
Flies, 87
Forest pests, 86
Forest tent caterpillars, 84
Fossils, Gebhard collection, 34
Fruit tree pests, 84

Gall midges, 87–88
Gaspé peninsula, geology of, 74–79
Gebhard collection of fossils, 34
Geographic Names, Board of, 43–44
Geological history of New York State, 106
Geology, bulletins, 104; in press, 106
Geology collections, 29; accessions, 113
Gipsy moth, 85
Grain moth, 86
Grass and grain pests, 86

Helderberg mountains, Indian Ladder Park, 40
Hemlock borer, spotted, 87
Hickory bark beetle, 86
Hopkins, Syracuse quadrangle, 59
House, H. D., assistant in botany, report of, 80–83

Digitized by Google

Indian collections, 34, 93–97, 130
Indian Ladder Park, Helderberg mountains, 40
Industrial geology, 69–73
Irondequoit pipe, *illus.*, 100

Lined corn borer, 86
Lockport quadrangle, 59
Luther, D. D., Attica and Depew quadrangles, 58; field surveys, 59

Maples, dry weather damage to, 80–81; new fungus enemy, 81–82
Martin, J. C., work on Canton quadrangle, 62–67
Memoirs, 104, 106
Miller, W. J., bulletin on Geological history of New York, 59; North Creek quadrangle, 59; survey of Blue Mountain quadrangle, 59–61
Miner, Roy W., checklist of the myriapods of New York, 92
Mineral springs and fault at Saratoga, 36–37
Mineralogy, 73; collections in, 29; accessions to collections, 113–15
Minerals, Silas A. Young collection, 34
Mining and quarry industry of New York State, 70–71, 104
Mohawk valley, lower Siluric shales, 104
Molding sand, 71–73
Mollusca, monograph of the New York, 92
Mormon hill, near Palmyra, 39; model of, 35
Mosquitos, 87
Museum cases, 5–28
Museum halls, condition of, 4
Myriapods of New York, 92

New Museum, condition of, 4
Newland, D. H., mining and quarry industry of New York State, 104
North Creek quadrangle, 59, 106
Notebook of the New York State Geological Survey, 40–42
Nursery inspection, 89

Ogdensburg quadrangle, 61–62
Olcott quadrangle, 59
Origin of man, paper by E. Rivet, 143–56

Paleontology, bulletins, 104, 106; collections in, 30–32, 115–16; memoirs, 104; report on, 73–79
Parker, Arthur C., Code of Handsome Lake, the Seneca prophet, 105
Paulmier, Frederick C., checklist of the myriapods of New York, 92
Pear psylla, 85
Pear thrips, 85
Petroleum compounds as insecticides, 84
Pilsbry, H. A., Monograph of the New York Mollusca, 92
Place names of Albany county, 44–50; Rensselaer county, 50–56; Schenectady county, 56–58
Publications, 103–7

Red bugs, 85
Rensselaer county, place names, 50–56
Rhododendron clearwing, 87
Rivet, E., The origin of man, paper, 143–56
Ruedemann, Rudolf, Lower Siluric shales of the Mohawk valley, 104
—— & Cushing, H. P., Saratoga and Schuylerville quadrangles, 59

San José scale, 84
Saratoga and Schuylerville quadrangles, 59
Saratoga Springs, geology, 36–37, 106
Schenectady county, place names, 56–58
Shade tree insects, 86
Staff of the Department of Science, 109–10
Stark's knob, Saratoga county, 37–38
Stone face from Chemung county, *illus.*, 97

Digitized by Google

Surficial geology, 67–69
Syracuse quadrangle, 59, 106

Taylor, Richard C., geological sketches from an old notebook, 40–41; sketch of, 41–42
Tent caterpillars, 84
Termier, Pierre, on geology of Gaspé peninsula, 74–79
Tulip tree scale, 86

White pine weevil, 87
Wierman, Thomas T., geological sketches in possession of, 40–42

Young, Silas A., collection of minerals, 34

Zoology, report on, 90–92; collections, 32; accessions to collections, 125–30

Digitized by Google

Digitized by Google

The University of the State of New York

New York State Museum

JOHN M. CLARKE, Director

PUBLICATIONS

Packages will be sent prepaid except when distance or weight renders the same impracticable. On 10 or more copies of any one publication 20% discount will be given. Editions printed are only large enough to meet special claims and probable sales. When the sale copies are exhausted, the price for the few reserve copies is advanced to that charged by second-hand booksellers, in order to limit their distribution to cases of special need. Such prices are inclosed in [ ]. All publications are in paper covers, unless binding is specified. Checks or money orders should be addressed and payable to The University of the State of New York.

Museum annual reports 1847–date. *All in print to* 1894, 50c *a volume*, 75c *in cloth;* 1894–*date, sold in sets only;* 75c *each for octavo volumes; price of quarto volumes on application.*

These reports are made up of the reports of the Director, Geologist, Paleontologist, Botanist and Entomologist, and museum bulletins and memoirs, issued as advance sections of the reports.

Director's annual reports 1904–date.

1904.	138p. 20c.		1909.	230p. 41pl. 2 maps, 4 charts.	*Out of print*
1905.	102p. 23pl. 30c.		1910.	280p. il. 42pl. 50c.	
1906.	186p. 41pl. 25c.		1911.	218p. 49pl. 50c.	
1907.	212p. 63pl. 50c.		1912.	214p. 50pl. 50c.	
1908.	234p. 39pl. map. 40c.		1913.	158p. il. 29pl. 40c.	

These reports cover the reports of the State Geologist and of the State Paleontologist. Bound also with the museum reports of which they form a part.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, 8vo; 2, 14–16, 4to.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–84, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

Report	*Price*	*Report*	*Price*	*Report*	*Price*
12 (1892)	$.50	17	$.75	21	$.40
14	.75	18	.75	22	.40
15, 2v.	2	19	.40	23	.45
16	1	20	.50	[*See* Director's annual reports]	

Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with the Director's report.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882–date.

Reports 3–20 bound also with museum reports 40–46, 48–58 of which they form a part. Since 1898 these reports have been issued as bulletins. Reports 3–4, 17 are out of print, other reports with prices are:

Report	*Price*	*Report*	*Price*	*Report*	*Price*
1	$.50	11	$.25	21 (Bul. 104)	$.25
2	.30	12	.25	22 (" 110)	.25
5	.25	13	*Out of print*	23 (" 124)	.75
6	.15	14 (Bul. 23)	.20	24 (" 134)	.35
7	.20	15 (" 31)	.15	25 (" 141)	.35
8	.25	16 (" 36)	.25	26 (" 147)	.35
9	.25	18 (" 64)	.20	27 (" 155)	.40
10	.35	19 (" 67)	.15	28 (" 165)	.40
		20 (" 97)	.40		

Digitized by Google

Reports 2, 8–12 may also be obtained bound in cloth at 25c each in addition to the price given above.

Botanist's annual reports 1867–date.

Bound also with museum reports 21–date of which they form a part; the first Botanist's report appeared in the 21st museum report and is numbered 21. Reports 21–24, 29, 31–41 were not published separately.

Separate reports for 1871–74, 1876, 1888–98 are out of print. Report for 1899 may be had for 20c; 1900 for 50c. Since 1901 these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), in volume 4 of the 56th (1902), in volume 2 of the 57th (1903), in volume 4 of the 58th (1904), in volume 2 of the 59th (1905), in volume 1 of the 60th (1906), in volume 2 of the 61st (1907), 62d (1908), 63d (1909), 64th (1910), 65th (1911) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum Memoir 4.

Museum bulletins 1887–date. 8vo. *To advance subscribers,* $2 *a year, or* $1 *a year for division* (1) *geology, economic geology, paleontology, mineralogy;* 50c *each for division* (2) *general zoology, archeology, miscellaneous,* (3) *botany,* (4) *entomology.*

Bulletins are grouped in the list on the following pages according to divisions. The divisions to which bulletins belong are as follows:

1 Zoology
2 Botany
3 Economic Geology
4 Mineralogy
5 Entomology
6 "
7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 "
12 "
13 Entomology
14 Geology
15 Economic Geology
16 Archeology
17 Economic Geology
18 Archeology
19 Geology
20 Entomology
21 Geology
22 Archeology
23 Entomology
24 "
25 Botany
26 Entomology
27 "
28 Botany
29 Zoology
30 Economic Geology
31 Entomology
32 Archeology
33 Zoology
34 Geology
35 Economic Geology
36 Entomology
37 "
38 Zoology
39 Paleontology
40 Zoology
41 Archeology
42 Geology
43 Zoology
44 Economic Geology
45 Paleontology
46 Entomology
47 "
48 Geology
49 Paleontology
50 Archeology
51 Zoology
52 Paleontology
53 Entomology
54 Botany
55 Archeology
56 Geology
57 Entomology
58 Mineralogy
59 Entomology
60 Zoology
61 Economic Geology
62 Miscellaneous
63 Geology
64 Entomology
65 Paleontology
66 Miscellaneous
67 Botany
68 Entomology
69 Paleontology
70 Mineralogy
71 Zoology
72 Entomology
73 Archeology
74 Entomology
75 Botany
76 Entomology
77 Geology
78 Archeology
79 Entomology
80 Paleontology
81 Geology
82 "
83 "
84 "
85 Economic Geology
86 Entomology
87 Archeology
88 Zoology
89 Archeology
90 Paleontology
91 Zoology
92 Paleontology
93 Economic Geology
94 Botany
95 Geology
96 "
97 Entomology
98 Mineralogy
99 Paleontology
100 Economic Geology
101 Paleontology
102 Economic Geology
103 Entomology
104 "
105 Botany
106 Geology
107 Geology and Paleontology
108 Archeology
109 Entomology
110 "
111 Geology
112 Economic Geology
113 Archeology
114 Geology
115 Geology
116 Botany
117 Archeology
118 Geology
119 Economic Geology
120 "
121 Director's report for 1907
122 Botany
123 Economic Geology
124 Entomology
125 Archeology
126 Geology
127 "
128 "
129 Entomology
130 Zoology
131 Botany
132 Economic Geology
133 Director's report for 1908
134 Entomology
135 Geology
136 Entomology
137 Geology
138 "
139 Botany
140 Director's report for 1909
141 Entomology
142 Economic Geology
143 "
144 Archeology
145 Geology
146 "
147 Entomology
148 Geology
149 Director's report for 1910
150 Botany
151 Economic Geology
152 Geology
153 "
154 "
155 Entomology
156 "
157 Botany
158 Director's report for 1911
159 Geology
160 "
161 Economic Geology
162 Geology
163 Archeology
164 Director's report for 1912
165 Entomology
166 Economic Geology
167 Botany
168 Geology
169 "
170 "
171 "
172 "
173 Director's report for 1913

Digitized by Google

Bulletins are also found with the annual reports of the museum as follows:

Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
12–15	48, v. 1	79	57, v. 1, pt 2	118	60, v. 1	153	64, v. 2
16,17	50, v. 1	80	57, v. 1, pt 1	119–21	61, v. 1	154	64, v. 2
18,19	51, v. 1	81,82	58, v. 3	122	61, v. 2	155	65, v. 2
20–25	52, v. 1	83,84	58, v. 1	123	61, v. 1	156	65, v. 2
26–31	53, v. 1	85	58, v. 2	124	61, v. 2	157	65, v. 2
32–34	54, v. 1	86	58, v. 5	125	62, v. 3	158	65, v. 1
35,36	54, v. 2	87–89	58, v. 4	126–28	62, v. 1	159	65, v. 1
37–44	54, v. 3	90	58, v. 3	129	62, v. 2	160	65, v. 1
45–48	54, v. 4	91	58, v. 4	130	62, v. 3	161	65, v. 2
49–54	55, v. 1	92	58, v. 3	131,132	62, v. 2	162	65, v. 1
55	56, v. 4	93	58, v. 2	133	62, v. 1	163	66, v. 2
56	56, v. 1	94	58, v. 4	134	62, v. 2	164	66, v. 1
57	56, v. 3	95,96	58, v. 1	135	63, v. 1	165–67	66, v. 2
58	56, v. 1	97	58, v. 5	136	63, v. 2	168–70	66, v. 1
59,60	56, v. 3	98,99	59, v. 2	137	63, v. 1		
61	56, v. 1	100	59, v. 1	138	63, v. 1	*Memoir*	
62	56, v. 4	101	59, v. 2	139	63, v. 2	2	49, v. 3
63	56, v. 2	102	59, v. 1	140	63, v. 1	3,4	53, v. 2
64	56, v. 3	103–5	59, v. 2	141	63, v. 2	5,6	57, v. 3
65	56, v. 2	106	59, v. 1	142	63, v. 2	7	57, v. 4
66,67	56, v. 4	107	60, v. 2	143	63, v. 2	8, pt 1	59, v. 3
68	56, v. 3	108	60, v. 3	144	64, v. 2	8, pt 2	59, v. 4
69	56, v. 2	109,110	60, v. 1	145	64, v. 1	9, pt 1	60, v. 4
70,71	57, v. 1, pt 1	111	60, v. 2	146	64, v. 1	9, pt 2	62, v. 4
72	57, v. 1, pt 2	112	60, v. 1	147	64, v. 2	10	60, v. 5
73	57, v. 2	113	60, v. 3	148	64, v. 2	11	61, v. 3
74	57, v. 1, pt 2	114	60, v. 1	149	64, v. 1	12	63, v. 3
75	57, v. 2	115	60, v. 2	150	64, v. 2	13	63, v. 4
76	57, v. 1, pt 2	116	60, v. 1	151	64, v. 2	14, v. 1	65, v. 3
77	57, v. 1, pt 1	117	60, v. 3	152	64, v. 2	14, v. 2	65, v. 4
78	57, v. 2						

The figures at the beginning of each entry in the following list indicate its number as a museum bulletin.

Geology and Paleontology. 14 Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co., N. Y., with notes on the iron mines. 38p. il. 7pl. 2 maps. Sept. 1895. Free.

19 Merrill, F. J. H. Guide to the Study of the Geological Collections of the New York State Museum. 164p. 119pl. map. Nov. 1898. *Out of print.*

21 Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sept. 1898. Free.

34 Cumings, E. R. Lower Silurian System of Eastern Montgomery County; Prosser, C. S. Notes on the Stratigraphy of Mohawk Valley and Saratoga County, N. Y. 74p. 14pl. map. May 1900. 15c.

39 Clarke, J. M.; Simpson, G. B. & Loomis, F. B. Paleontologic Papers 1. 72p. il. 16pl. Oct. 1900. 15c.

Contents: Clarke, J. M. A Remarkable Occurrence of Orthoceras in the Oneonta Beds of the Chenango Valley, N. Y.
—— Paropsonema cryptophya; a Peculiar Echinoderm from the Intumescens-zone (Portage Beds) of Western New York.
—— Dictyonine Hexactinellid Sponges from the Upper Devonic of New York.
—— The Water Biscuit of Squaw Island, Canandaigua Lake, N. Y.
Simpson, G. B. Preliminary Descriptions of New Genera of Paleozoic Rugose Corals.
Loomis, F. B. Siluric Fungi from Western New York.

42 Ruedemann, Rudolf. Hudson River Beds near Albany and their Taxonomic Equivalents. 116p. 2pl. map. Apr. 1901. 25c.

45 Grabau, A. W. Geology and Paleontology of Niagara Falls and Vicinity. 286p. il. 18pl. map. Apr. 1901. 65c; *cloth*, 90c.

48 Woodworth, J. B. Pleistocene Geology of Nassau County and Borough of Queens. 58p. il. 8pl. map. Dec. 1901. 25c.

49 Ruedemann, Rudolf; Clarke, J. M. & Wood, Elvira. Paleontologic Papers 2. 240p. 13pl. Dec. 1901. *Out of print.*

Contents: Ruedemann, Rudolf. Trenton Conglomerate of Rysedorph Hill.
Clarke, J. M. Limestones of Central and Western New York Interbedded with Bituminous Shales of the Marcellus Stage.
Wood, Elvira. Marcellus Limestones of Lancaster, Erie Co., N. Y.
Clarke, J. M. New Agelacrinites.
—— Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonic of New York, Ireland and the Rhineland.

52 Clarke, J. M. Report of the State Paleontologist 1901. 280p. il. 10pl. map, 1 tab. July 1902. 40c.

56 Merrill, F. J. H. Description of the State Geologic Map of 1901. 42p. 2 maps, tab. Nov. 1902. Free.

Digitized by Google

63 Clarke, J. M. & Luther, D. D. Stratigraphy of Canandaigua and Naples Quadrangles. 78p. map. June 1904. 25c.

65 Clarke, J. M. Catalogue of Type Specimens of Paleozoic Fossils in the New York State Museum. 848p. May 1903. $1.20, *cloth.*

69 —— Report of the State Paleontologist 1902. 464p. 52pl. 7 maps. Nov. 1903. $1, *cloth.*

77 Cushing, H. P. Geology of the Vicinity of Little Falls, Herkimer Co. 98p. il. 15pl. 2 maps. Jan. 1905. 30c.

80 Clarke, J. M. Report of the State Paleontologist 1903. 396p. 29pl. 2 maps. Feb. 1905. 85c, *cloth.*

81 Clarke, J. M. & Luther, D. D. Watkins and Elmira Quadrangles. 32p. map. Mar. 1905. 25c.

82 —— Geologic Map of the Tully Quadrangle. 40p. map. Apr. 1905. 20c.

83 Woodworth, J. B. Pleistocene Geology of the Mooers Quadrangle. 62p. 25pl. map. June 1905. 25c.

84 —— Ancient Water Levels of the Champlain and Hudson Valleys. 206p. il. 11pl. 18 maps. July 1905. 45c.

90 Ruedemann, Rudolf. Cephalopoda of Beekmantown and Chazy Formations of Champlain Basin. 224p. il. 38pl. May 1906. 75c, *cloth.*

92 Grabau, A. W. Guide to the Geology and Paleontology of the Schoharie Region. 314p. il. 26pl. map. Apr. 1906. 75c, *cloth.*

95 Cushing, H. P. Geology of the Northern Adirondack Region. 188p. 15pl. 3 maps. Sept. 1905. 30c.

96 Ogilvie, I. H. Geology of the Paradox Lake Quadrangle. 54p. il. 17pl. map. Dec. 1905. 30c.

99 Luther, D. D. Geology of the Buffalo Quadrangle. 32p. map. May 1906. 20c.

101 —— Geology of the Penn Yan-Hammondsport Quadrangles. 28p. map. July 1906. *Out of print.*

106 Fairchild, H. L. Glacial Waters in the Erie Basin. 88p. 14pl. 9 maps. Feb. 1907. *Out of print.*

107 Woodworth, J. B.; Hartnagel, C. A.; Whitlock, H. P.; Hudson, G. H.; Clarke, J. M.; White, David & Berkey, C. P. Geological Papers. 388p. 54pl. map. May 1907. 90c, *cloth.*

Contents: Woodworth, J. B. Postglacial Faults of Eastern New York.
Hartnagel, C. A. Stratigraphic Relations of the Oneida Conglomerate.
—— Upper Siluric and Lower Devonic Formations of the Skunnemunk Mountain Region.
Whitlock, H. P. Minerals from Lyon Mountain, Clinton Co.
Hudson, G. H. On Some Pelmatozoa from the Chazy Limestone of New York.
Clarke, J. M. Some New Devonic Fossils.
—— An Interesting Style of Sand-filled Vein.
—— Eurypterus Shales of the Shawangunk Mountains in Eastern New York.
White, David. A Remarkable Fossil Tree Trunk from the Middle Devonic of New York.
Berkey, C. P. Structural and Stratigraphic Features of the Basal Gneisses of the Highlands.

111 Fairchild, H. L. Drumlins of New York. 60p. 28pl. 19 maps. July 1907. *Out of print.*

114 Hartnagel, C. A. Geologic Map of the Rochester and Ontario Beach Quadrangles. 36p. map. Aug. 1907. 20c.

115 Cushing, H. P. Geology of the Long Lake Quadrangle. 88p. 20pl. map. Sept. 1907. *Out of print.*

118 Clarke, J. M. & Luther, D. D. Geologic Maps and Descriptions of the Portage and Nunda Quadrangles including a map of Letchworth Park. 50p. 16pl. 4 maps. Jan. 1908. 35c.

126 Miller, W. J. Geology of the Remsen Quadrangle. 54p. il. 11pl. map. Jan. 1909. 25c.

127 Fairchild, H. L. Glacial Waters in Central New York. 64p. 27pl. 15 maps. Mar. 1909. 40c.

128 Luther, D. D. Geology of the Geneva-Ovid Quadrangles. 44p. map. Apr. 1909. 20c.

135 Miller, W. J. Geology of the Port Leyden Quadrangle, Lewis County, N. Y. 62p. il. 11pl. map. Jan. 1910. 25c.

137 Luther, D. D. Geology of the Auburn-Genoa Quadrangles. 36p. map. Mar. 1910. 20c.

138 Kemp, J. F. & Ruedemann, Rudolf. Geology of the Elizabethtown and Port Henry Quadrangles. 176p. il. 20pl. 3 maps. Apr. 1910. 40c

Digitized by Google

145 Cushing, H. P.; Fairchild, H. L.; Ruedemann, Rudolf & Smyth, C. H. Geology of the Thousand Islands Region. 194p. il. 62pl. 6 maps. Dec. 1910. 75c.
146 Berkey, C. P. Geologic Features and Problems of the New York City (Catskill) Aqueduct. 286p. il. 38pl. maps. Feb. 1911. 75c; *cloth*, $1.
148 Gordon, C. E. Geology of the Poughkeepsie Quadrangle. 122p. il. 26pl. map. Apr. 1911. 30c.
152 Luther, D. D. Geology of the Honeoye-Wayland Quadrangles. 30p. map. Oct. 1911. 20c.
153 Miller, William J. Geology of the Broadalbin Quadrangle, Fulton-Saratoga Counties, New York. 66p. il. 8 pl. map. Dec. 1911. 25c.
154 Stoller, James H. Glacial Geology of the Schenectady Quadrangle. 44p. 9 pl. map. Dec. 1911. 20c.
159 Kemp, James F. The Mineral Springs of Saratoga. 80p. il. 3pl. Apr. 1912. 15c.
160 Fairchild, H. L. Glacial Waters in the Black and Mohawk Valleys. 48p. il. 8pl. 14 maps. May 1912. 50c.
162 Ruedemann, Rudolf. The Lower Siluric Shales of the Mohawk Valley. 152p. il. 15pl. Aug. 1912. 35c.
168 Miller, William J. Geological History of New York State. 130p. 43pl. 10 maps. Dec. 1913. 40c.
169 Cushing, H. P. & Ruedemann, Rudolf. Geology of Saratoga Springs and Vicinity. 178p. il. 20 pl. map. Feb. 1914. 40c.
170 Miller, William J. Geology of the North Creek Quadrangle. 90p. il. 14pl. Feb. 1914. 25c.
171 Hopkins, T. C. The Geology of the Syracuse Quadrangle. 80p. il. 20pl. map. July 1914. 25c.
172 Luther, D. D. Geology of the Attica and Depew Quadrangles. 32p. map. August 1914. 15c.
Luther, D. D. Geology of the Phelps Quadrangle. *In preparation.*
Whitnall, H. O. Geology of the Morrisville Quadrangle. *Prepared.*
Hudson, G. H. Geology of Valcour Island. *In preparation.*

Economic Geology.

3 Smock, J. C. Building Stone in the State of New York. 154p. Mar. 1888. *Out of print.*
7 —— First Report on the Iron Mines and Iron Ore Districts in the State of New York. 78p. map. June 1889. *Out of print.*
10 —— Building Stone in New York. 210p. map, tab. Sept. 1890. 40c.
11 Merrill, F. J. H. Salt and Gypsum Industries of New York. 94p. 12pl. 2 maps, 11 tab. Apr. 1893. [50c]
12 Ries, Heinrich. Clay Industries of New York. 174p. il. 1pl. map. Mar. 1895. 30c.
15 Merrill, F. J. H. Mineral Resources of New York. 240p. 2 maps. Sept. 1895. [50c]
17 —— Road Materials and Road Building in New York. 52p. 14pl. 2 maps. Oct. 1897. 15c.
30 Orton, Edward. Petroleum and Natural Gas in New York. 136p. il. 3 maps. Nov. 1899. 15c.
35 Ries, Heinrich. Clays of New York; their Properties and Uses. 456p. 140pl. map. June 1900. *Out of print.*
44 —— Lime and Cement Industries of New York; Eckel, E. C. Chapters on the Cement Industry. 332p. 101pl. 2 maps. Dec. 1901. 85c, *cloth.*
61 Dickinson, H. T. Quarries of Bluestone and Other Sandstones in New York. 114p. 18pl. 2 maps. Mar. 1903. 35c.
85 Rafter, G. W. Hydrology of New York State. 902p. il. 44pl. 5 maps. May 1905. $1.50, *cloth.*
93 Newland, D. H. Mining and Quarry Industry of New York. 78p. July 1905. *Out of print.*
100 McCourt, W. E. Fire Tests of Some New York Building Stones. 40p. 26pl. Feb. 1906. 15c.
102 Newland, D. H. Mining and Quarry Industry of New York 1905. 162p. June 1906. 25c.
112 —— Mining and Quarry Industry of New York 1906. 82p. July 1907. *Out of print.*

Digitized by Google

119 —— & Kemp, J. F. Geology of the Adirondack Magnetic Iron Ores with a Report on the Mineville-Port Henry Mine Group. 184p. 14pl. 8 maps. Apr. 1908. 35c.
120 Newland, D. H. Mining and Quarry Industry of New York 1907. 82p. July 1908. *Out of print.*
123 —— & Hartnagel, C. A. Iron Ores of the Clinton Formation in New York State. 76p. il. 14pl. 3 maps. Nov. 1908. 25c.
132 Newland, D. H. Mining and Quarry Industry of New York 1908. 98p. July 1909. 15c.
142 —— Mining and Quarry Industry of New York for 1909. 98p. Aug. 1910. 15c.
143 —— Gypsum Deposits of New York. 94p. 20pl. 4 maps. Oct. 1910 35c.
151 —— Mining and Quarry Industry of New York 1910. 82p. June 1911. 15c.
161 —— Mining and Quarry Industry of New York 1911. 114p. July 1912. 20c.
166 —— Mining and Quarry Industry of New York 1912. 114p. August 1913. 20c.
—— Mining and Quarry Industry of New York 1913. *In press.*

Mineralogy. 4 Nason, F. L. Some New York Minerals and their Localities. 22p. 1pl. Aug. 1888. Free.
58 Whitlock, H. P. Guide to the Mineralogic Collections of the New York State Museum. 150p. il. 39pl. 11 models. Sept. 1902. 40c.
70 —— New York Mineral Localities. 110p. Oct. 1903. 20c.
98 —— Contributions from the Mineralogic Laboratory. 38p. 7pl. Dec. 1905. *Out of print.*

Zoology. 1 Marshall, W. B. Preliminary List of New York Unionidae. 20p. Mar. 1892. Free.
9 —— Beaks of Unionidae Inhabiting the Vicinity of Albany, N. Y. 30p. 1pl. Aug. 1890. Free.
29 Miller, G. S., jr. Preliminary List of New York Mammals. 124p. Oct. 1899. 15c.
33 Farr, M. S. Check List of New York Birds. 224p. Apr. 1900. 25c.
38 Miller, G. S., jr. Key to the Land Mammals of Northeastern North America. 106p. Oct. 1900. *Out of print.*
40 Simpson, G. B. Anatomy and Physiology of Polygyra albolabris and Limax maximus and Embryology of Limax maximus. 82p. 28pl. Oct. 1901. 25c.
43 Kellogg, J. L. Clam and Scallop Industries of New York. 36p. 2pl. map. Apr. 1901. Free.
51 Eckel, E. C. & Paulmier, F. C. Catalogue of Reptiles and Batrachians of New York. 64p. il. 1pl. Apr. 1902. *Out of print.*

Eckel, E. C. Serpents of Northeastern United States.
Paulmier, F. C. Lizards, Tortoises and Batrachians of New York.

60 Bean, T. H. Catalogue of the Fishes of New York. 784p. Feb. 1903. $1, *cloth.*
71 Kellogg, J. L. Feeding Habits and Growth of Venus mercenaria. 30p. 4pl. Sept. 1903. Free.
88 Letson, Elizabeth J. Check List of the Mollusca of New York. 116p. May 1905. 20c.
91 Paulmier, F. C. Higher Crustacea of New York City. 78p. il. June 1905. 20c.
130 Shufeldt, R. W. Osteology of Birds. 382p. il. 26pl. May 1909. 50c.

Entomology. 5 Lintner, J. A. White Grub of the May Beetle. 34p. il. Nov. 1888. Free.
6 —— Cut-worms. 38p. il. Nov. 1888. Free.
13 —— San José Scale and Some Destructive Insects of New York State. 54p. 7pl. Apr. 1895. 15c.
20 Felt, E. P. Elm Leaf Beetle in New York State. 46p. il. 5pl. June 1898. Free.

See 57.

23 —— 14th Report of the State Entomologist 1898. 150p. il. 9pl. Dec. 1898. 20c.
24 —— Memorial of the Life and Entomologic Work of J. A. Lintner Ph.D. State Entomologist 1874–98; Index to Entomologist's Reports 1–13. 316p. 1pl. Oct. 1899. 35c.

Supplement to 14th report of the State Entomologist.

Digitized by Google

26 —— Collection, Preservation and Distribution of New York Insects. 36p. il. Apr. 1899. *Out of print.*
27 —— Shade Tree Pests in New York State. 26p. il. 5pl. May 1899. Free.
31 —— 15th Report of the State Entomologist 1899. 128p. June 1900. 15c.
36 —— 16th Report of the State Entomologist 1900. 118p. 16pl. Mar. 1901. 25c.
37 —— Catalogue of Some of the More Important Injurious and Beneficial Insects of New York State. 54p. il. Sept. 1900. Free.
46 —— Scale Insects of Importance and a List of the Species in New York State. 94p. il. 15pl. June 1901. 25c.
47 Needham, J. G. & Betten, Cornelius. Aquatic Insects in the Adirondacks. 234p. il. 36pl. Sept. 1901. 45c.
53 Felt, E. P. 17th Report of the State Entomologist 1901. 232p. il. 6pl. Aug. 1902. *Out of print.*
57 —— Elm Leaf Beetle in New York State. 46p. il. 8pl. Aug. 1902. *Out of print.*

This is a revision of Bulletin 20 containing the more essential facts observed since that was prepared.

59 —— Grapevine Root Worm. 40p. 6pl. Dec. 1902. 15c.

See 72.

64 —— 18th Report of the State Entomologist 1902. 110p. 6pl. May 1903. 20c.
68 Needham, J. G. *& others.* Aquatic Insects in New York. 322p. 52pl. Aug. 1903. 80c, *cloth.*
72 Felt, E. P. Grapevine Root Worm. 58p. 13pl. Nov. 1903. 20c.

This is a revision of Bulletin 59 containing the more essential facts observed since that was prepared.

74 —— & Joutel, L. H. Monograph of the Genus Saperda. 88p. 14pl. June 1904. 25c.
76 Felt, E. P. 19th Report of the State Entomologist 1903. 150p. 4pl. 1904. 15c.
79 —— Mosquitos or Culicidae of New York. 164p. il. 57pl. tab. Oct. 1904. 40c.
86 Needham, J. G. *& others.* May Flies and Midges of New York. 352p. il. 37pl. June 1905. *Out of print.*
97 Felt, E. P. 20th Report of the State Entomologist 1904. 246p. il. 19pl. Nov. 1905. 40c.
103 —— Gipsy and Brown Tail Moths. 44p. 10pl. July 1906. 15c.
104 —— 21st Report of the State Entomologist 1905. 144p. 10pl. Aug. 1906. 25c.
109 —— Tussock Moth and Elm Leaf Beetle. 34p. 8pl. Mar. 1907. 20c.
110 —— 22d Report of the State Entomologist 1906. 152p. 3pl. June 1907. 25c.
124 —— 23d Report of the State Entomologist 1907. 542p. il. 44pl. Oct. 1908. 75c.
129 —— Control of Household Insects. 48p. il. May 1909. *Out of print.*
134 —— 24th Report of the State Entomologist 1908. 208p. il. 17pl. Sept. 1909. 35c.
136 —— Control of Flies and Other Household Insects. 56p. il. Feb. 1910. 15c.

This is a revision of Bulletin 129 containing the more essential facts observed since that was prepared.

141 Felt, E. P. 25th Report of the State Entomologist 1909. 178p. il. 22pl. July 1910. 35c.
147 —— 26th Report of the State Entomologist 1910. 182p. il. 35pl. Mar. 1911. 35c.
155 —— 27th Report of the State Entomologist 1911. 198p. il. 27pl. Jan. 1912. 40c.
156 —— Elm Leaf Beetle and White-Marked Tussock Moth. 35p. 8pl. Jan. 1912. 20c.
165 —— 28th Report of the State Entomologist 1912. 266p. 14pl. July 1913. 40c.
—— 29th Report of the State Entomologist 1913. *In press.*

Digitized by Google

Needham, J. G. Monograph on Stone Flies. *In preparation.*

Botany. 2 Peck, C. H. Contributions to the Botany of the State of New York. 72p. 2pl. May 1887. *Out of print.*

8 —— Boleti of the United States. 98p. Sept. 1889. *Out of print.*

25 —— Report of the State Botanist 1898. 76p. 5pl. Oct. 1899. *Out of print.*

28 —— Plants of North Elba. 206p. map. June 1899. 20c.

54 —— Report of the State Botanist 1901. 58p. 7pl. Nov. 1902. 40c.

67 —— Report of the State Botanist 1902. 196p. 5pl. May 1903. 50c.

75 —— Report of the State Botanist 1903. 70p. 4pl. 1904. 40c.

94 —— Report of the State Botanist 1904. 60p. 10pl. July 1905. 40c.

105 —— Report of the State Botanist 1905. 108p. 12pl. Aug. 1906. 50c.

116 —— Report of the State Botanist 1906. 120p. 6pl. July 1907. 35c.

122 —— Report of the State Botanist 1907. 178p. 5pl. Aug. 1908. 40c.

131 —— Report of the State Botanist 1908. 202p. 4pl. July 1909. 40c.

139 —— Report of the State Botanist 1909. 116p. 10pl. May 1910. 45c.

150 —— Report of the State Botanist 1910. 100p. 5pl. May 1911. 30c.

157 —— Report of the State Botanist 1911. 139p. 9pl. Mar. 1912. 35c.

167 —— Report of the State Botanist 1912. 138p. 4pl. Sept. 1913. 30c.

Report of the State Botanist 1913. *In press.*

Archeology. 16 Beauchamp, W. M. Aboriginal Chipped Stone Implements of New York. 86p. 23pl. Oct. 1897. 25c.

18 —— Polished Stone Articles Used by the New York Aborigines. 104p. 35pl. Nov. 1897. 25c.

22 —— Earthenware of the New York Aborigines. 78p. 33pl. Oct. 1898. 25c.

32 —— Aboriginal Occupation of New York. 190p. 16pl. 2 maps. Mar. 1900. 30c.

41 —— Wampum and Shell Articles Used by New York Indians. 166p. 28pl. Mar. 1901. *Out of print.*

50 —— Horn and Bone Implements of the New York Indians. 112p. 43pl. Mar. 1902. *Out of print.*

55 —— Metallic Implements of the New York Indians. 94p. 38pl. June 1902. 25c.

73 —— Metallic Ornaments of the New York Indians. 122p. 37pl. Dec. 1903. 30c.

78 —— History of the New York Iroquois. 340p. 17pl. map. Feb. 1905. 75c, *cloth.*

87 —— Perch Lake Mounds. 84p. 12pl. Apr. 1905. *Out of print.*

89 —— Aboriginal Use of Wood in New York. 190p. 35pl. June 1905. 35c.

108 —— Aboriginal Place Names of New York. 336p. May 1907. 40c.

113 —— Civil, Religious and Mourning Councils and Ceremonies of Adoption. 118p. 7pl. June 1907. 25c.

117 Parker, A. C. An Erie Indian Village and Burial Site. 102p. 38pl. Dec. 1907. 30c.

125 Converse, H. M. & Parker, A. C. Iroquois Myths and Legends. 196p. il. 11pl. Dec. 1908. 50c.

144 Parker, A. C. Iroquois Uses of Maize and Other Food Plants. 120p. il. 31pl. Nov. 1910. 30c.

163 —— The Code of Handsome Lake. 144p. 23pl. Nov. 1912. 25c.

Miscellaneous. 62 Merrill, F. J. H. Directory of Natural History Museums in United States and Canada. 236p. Apr. 1903. 30c.

66 Ellis, Mary. Index to Publications of the New York State Natural History Survey and New York State Museum 1837–1902. 418p. June 1903. 75c, *cloth.*

Museum memoirs 1889–date. 4to.

1 Beecher, C. E. & Clarke, J. M. Development of Some Silurian Brachiopoda. 96p. 8pl. Oct. 1889. $1.

2 Hall, James & Clarke, J. M. Paleozoic Reticulate Sponges. 350p. il. 70pl. 1898. $2, *cloth.*

3 Clarke, J. M. The Oriskany Fauna of Becraft Mountain, Columbia Co., N. Y. 128p. 9pl. Oct. 1900. 80c.

4 Peck, C. H. N. Y. Edible Fungi, 1895–99. 106p. 25pl. Nov. 1900. [$1.25]

This includes revised descriptions and illustrations of fungi reported in the 49th, 51st and 52d reports of the State Botanist.

Digitized by Google

5 Clarke, J. M. & Ruedemann, Rudolf. Guelph Formation and Fauna of New York State. 196p. 21pl. July 1903. $1.50, *cloth.*

6 Clarke, J. M. Naples Fauna in Western New York. 268p. 26pl. map. 1904. $2, *cloth.*

7 Ruedemann, Rudolf. Graptolites of New York. Pt 1 Graptolites of the Lower Beds. 350p. 17pl. Feb. 1905. $1.50, *cloth.*

8 Felt, E. P. Insects Affecting Park and Woodland Trees. v.1. 460p. il. 48pl. Feb. 1906. $2.50, *cloth*: v. 2. 548p. il. 22pl. Feb. 1907. $2, *cloth.*

9 Clarke, J. M. Early Devonic of New York and Eastern North America. Pt 1. 366p. il. 70pl. 5 maps. Mar. 1908. $2.50, *cloth*; Pt 2. 250p. il. 36pl. 4 maps. Sept. 1909. $2, *cloth.*

10 Eastman, C. R. The Devonic Fishes of the New York Formations. 236p. 15pl. 1907. $1.25, *cloth.*

11 Ruedemann, Rudolf. Graptolites of New York. Pt 2 Graptolites of the Higher Beds. 584p. il. 31pl. 2 tab. Apr. 1908. $2.50, *cloth.*

12 Eaton, E. H. Birds of New York. v. 1. 501p. il. 42pl. Apr. 1910. $3, *cloth*; v. 2, 719p. il. 64 pl. July 1914. $4, cloth.

13 Whitlock, H. P. Calcites of New York. 190p. il. 27pl. Oct. 1910. $1, *cloth.*

14 Clarke, J. M. & Ruedemann, Rudolf. The Eurypterida of New York. v. 1. Text. 440p. il. v. 2 Plates. 188p. 88pl. Dec. 1912. $4, *cloth.*

Natural History of New York. 30v. il. pl. maps. 4to. Albany 1842–94.

DIVISION 1 ZOOLOGY. De Kay, James E. Zoology of New York; or, The New York Fauna; comprising detailed descriptions of all the animals hitherto observed within the State of New York with brief notices of those occasionally found near its borders, and accompanied by appropriate illustrations. 5v. il. pl. maps. sq. 4to. Albany 1842–44. *Out of print.*

Historical introduction to the series by Gov. W. H. Seward. 178p.

v. 1 pt1 Mammalia. 131 + 46p. 33pl. 1842.

300 copies with hand-colored plates.

v. 2 pt2 Birds. 12 + 380p. 141pl. 1844.

Colored plates.

v. 3 pt3 Reptiles and Amphibia. 7 + 98p. pt 4 Fishes. 15 + 415p. 1842.

pt 3–4 bound together.

v. 4 Plates to accompany v. 3. Reptiles and Amphibia. 23pl. Fishes. 79pl. 1842.

300 copies with hand-colored plates.

v. 5 pt5 Mollusca. 4 + 271p. 40pl. pt 6 Crustacea. 70p. 13pl. 1843–44.

Hand-colored plates; pt5–6 bound together.

DIVISION 2 BOTANY. Torrey, John. Flora of the State of New York; comprising full descriptions of all the indigenous and naturalized plants hitherto discovered in the State, with remarks on their economical and medical properties. 2v. il. pl. sq. 4to. Albany 1843. *Out of print.*

v. 1 Flora of the State of New York. 12 + 484p. 72pl. 1843.

300 copies with hand-colored plates.

v. 2 Flora of the State of New York. 572p. 89pl. 1843.

300 copies with hand-colored plates.

DIVISION 3 MINERALOGY. Beck, Lewis C. Mineralogy of New York; comprising detailed descriptions of the minerals hitherto found in the State of New York, and notices of their uses in the arts and agriculture. il. pl. sq. 4to. Albany 1842. *Out of print.*

v. 1 pt1 Economical Mineralogy. pt2 Descriptive Mineralogy. 24 + 536p. 1842.

8 plates additional to those printed as part of the text.

DIVISION 4 GEOLOGY. Mather, W. W.; Emmons, Ebenezer; Vanuxem, Lardner & Hall, James. Geology of New York. 4v. il. pl. sq. 4to. Albany 1842–43. *Out of print.*

v. 1 pt1 Mather, W. W. First Geological District. 37 + 653p. 46pl. 1843.

v. 2 pt2 Emmons, Ebenezer. Second Geological District. 10 + 437p. 17pl. 1842.

v. 3 pt3 Vanuxem, Lardner. Third Geological District. 306p. 1842.

Digitized by Google

v 4 pt4 Hall, James. Fourth Geological District. 22 + 683p. 19pl. map. 1843.

DIVISION 5 AGRICULTURE. Emmons, Ebenezer. Agriculture of New York; comprising an account of the classification, composition and distribution of the soils and rocks and the natural waters of the different geological formations, together with a condensed view of the meteorology and agricultural productions of the State. 5v. il. pl. sq. 4to. Albany 1846–54. *Out of print.*

v. 1 Soils of the State, Their Composition and Distribution. 11 + 371p. 21pl. 1846.

v. 2 Analysis of Soils, Plants, Cereals, etc. 8 + 343 + 45p. 42pl. 1849.
With hand-colored plates.

v. 3 Fruits, etc. 8 + 340p. 1851.

v. 4 Plates to accompany v. 3. 95pl. 1851.
Hand-colored.

v. 5 Insects Injurious to Agriculture. 8 + 272p. 50pl. 1854.
With hand-colored plates.

DIVISION 6 PALEONTOLOGY. Hall, James. Paleontology of New York. 8v. il. pl. sq. 4to. Albany 1847–94. *Bound in cloth.*

v. 1 Organic Remains of the Lower Division of the New York System. 23 + 338p. 99pl. 1847. *Out of print.*

v. 2 Organic Remains of Lower Middle Division of the New York System. 8 + 362p. 104pl. 1852. *Out of print.*

v. 3 Organic Remains of the Lower Helderberg Group and the Oriskany Sandstone. pt 1, text. 12 + 532p. 1859. [$3.50]

—— pt 2. 142pl. 1861. [$2.50]

v. 4 Fossil Brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 11 + 1 + 428p. 69pl. 1867. $2.50.

v. 5 pt 1 Lamellibranchiata 1. Monomyaria of the Upper Helderberg, Hamilton and Chemung Groups. 18 + 268p. 45pl. 1884. $2.50.

—— —— Lamellibranchiata 2. Dimyaria of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 62 + 293p. 51pl. 1885. $2.50.

—— pt 2 Gasteropoda, Pteropoda and Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 2v. 1879. v. 1, text. 15 + 492p.; v.2. 120pl. $2.50 for 2 v.

—— & Simpson, George B. v. 6 Corals and Bryozoa of the Lower and Upper Helderberg and Hamilton Groups. 24 + 298p. 67pl. 1887. $2.50.

—— & Clarke, John M. v. 7 Trilobites and Other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. 64 + 236p. 46pl. 1888. Cont. supplement to v. 5, pt 2. Pteropoda, Cephalopoda and Annelida. 42p. 18pl. 1888. $2.50.

—— & Clarke, John M. v. 8 pt 1 Introduction to the Study of the Genera of the Paleozoic Brachiopoda. 16 + 367p. 44pl. 1892. $2.50.

—— & Clarke, John M. v. 8 pt 2 Paleozoic Brachiopoda. 16 + 394p. 64pl. 1894. $2.50.

Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. 8vo. 1853.

Handbooks 1893–date.

New York State Museum. 52p. il. 1902. **Free.**
Outlines, history and work of the museum with list of staff 1902.

Paleontology. 12p. 1899. *Out of print.*
Brief outline of State Museum work in paleontology under heads: Definition; Relation to biology; Relation to stratigraphy; History of paleontology in New York.

Guide to Excursions in the Fossiliferous Rocks of New York. 124p. 1899. *Out of print.*
Itineraries of 32 trips covering nearly the entire series of Paleozoic rocks, prepared specially for the use of teachers and students desiring to acquaint themselves more intimately with the classic rocks of this State.

Entomology. 16p. 1899. *Out of print.*

Economic Geology. 44p. 1904. Free.

Insecticides and Fungicides. 20p. 1909. **Free.**

Digitized by Google

Classification of New York Series of Geologic Formations. 32p. 1903. *Out of print.* Revised edition. 96p. 1912. Free.

Geologic maps. Merrill, F. J. H. Economic and Geologic Map of the State of New York; issued as part of Museum Bulletin 15 and 48th Museum Report, v. 1. 59 x 67 cm. 1894. Scale 14 miles to 1 inch. 15c.

—— Map of the State of New York Showing the Location of Quarries of Stone Used for Building and Road Metal. 1897. *Out of print.*

—— Map of the State of New York Showing the Distribution of the Rocks Most Useful for Road Metal. 1897. *Out of print.*

—— Geologic Map of New York. 1901. Scale 5 miles to 1 inch. *In atlas form* $3. *Lower Hudson sheet* 60c.

The lower Hudson sheet, geologically colored, comprises Rockland, Orange, Dutchess, Putnam, Westchester, New York, Richmond, Kings, Queens and Nassau counties, and parts of Sullivan, Ulster and Suffolk counties; also northeastern New Jersey and part of western Connecticut.

—— Map of New York Showing the Surface Configuration and Water Sheds. 1901. Scale 12 miles to 1 inch. 15c.

—— Map of the State of New York Showing the Location of Its Economic Deposits. 1904. Scale 12 miles to 1 inch. 15c.

Geologic maps on the United States Geological Survey topographic base. Scale 1 in. = 1 m. Those marked with an asterisk have also been published separately.

*Albany county. 1898. *Out of print.*
Area around Lake Placid. 1898.
Vicinity of Frankfort Hill [parts of Herkimer and Oneida counties]. 1899.
Rockland county. 1899.
Amsterdam quadrangle. 1900.
*Parts of Albany and Rensselaer counties. 1901. *Out of print.*
*Niagara river. 1901. 25c.
Part of Clinton county. 1901.
Oyster Bay and Hempstead quadrangles on Long Island. 1901.
Portions of Clinton and Essex counties. 1902.
Part of town of Northumberland, Saratoga co. 1903.
Union Springs, Cayuga county and vicinity. 1903.
*Olean quadrangle. 1903. Free.
*Becraft Mt with 2 sheets of sections. (Scale 1 in. = ½ m.) 1903. 20c.
*Canandaigua-Naples quadrangles. 1904. 20c.
*Little Falls quadrangle. 1905. Free.
*Watkins-Elmira quadrangles. 1905. 20c.
*Tully quadrangle. 1905. Free.
*Salamanca quadrangle. 1905. Free.
*Mooers quadrangle. 1905. Free.
Paradox Lake quadrangle. 1905.
*Buffalo quadrangle. 1906. Free.
*Penn Yan-Hammondsport quadrangles. 1906. 20c.
*Rochester and Ontario Beach quadrangles. 20c.
*Long Lake quadrangle. Free.
*Nunda-Portage quadrangles. 20c.
*Remsen quadrangle. 1908. Free.
*Geneva-Ovid quadrangles. 1909. 20c.
*Port Leyden quadrangle. 1910. Free.
*Auburn-Genoa quadrangles. 1910. 20c.
*Elizabethtown and Port Henry quadrangles. 1910. 15c.
*Alexandria Bay quadrangle. 1910. Free.
*Cape Vincent quadrangle. 1910. Free.
*Clayton quadrangle. 1910. Free.
*Grindstone quadrangle. 1910. Free.
*Theresa quadrangle. 1910. Free.
*Poughkeepsie quadrangle. 1911. Free.
*Honeoye-Wayland quadrangle. 1911. 20c.
*Broadalbin quadrangle. 1911. Free.
*Schenectady quadrangle. 1911. Free.
*Saratoga-Schuylerville quadrangles. 1914. 20c.
*North Creek quadrangle. 1914. Free.
*Syracuse quadrangle. 1914. Free.
*Attica-Depew quadrangles. 1914. 20c.

Digitized by Google

Digitized by Google

Digitized by Google

15
12
18

Digitized by Google

Digitized by Google

Digitized by Google

3 2044 106 303 464

Date Due

NOV 6 4 1947	DEC 1 7 1954
DEC 1 5 1947	
Aug'49	SEP 1970
SEP	
Oct 23	JUL 1975
JUL 1 4 1951	
APR 1 1 1952	
NOV 1 2 1952	
JUN 1 1 1953	
NOV 2 4 1953	
APR 1 9 1954	

Digitized by Google

Digitized by Google